Jinsha River Basin Project

Jinsha River Basin Integrated Water Resources and Risk Management under Changing Climate

Final Report
April 2018

Jinsha River Basin project is a Sino-Swiss cooperation
involving the public and private sectors of both countries.

Content

Annexes

1. Introduction

1.1 Sino-Swiss Cooperation

As a global environmental issue, climate change has received global political attention. Increased temperatures, rise of sea level, extreme weather and natural hazard events caused by climate change have had more and more serious impacts on natural ecosystems and societies. Climate change has become the political focus of the Chinese government leading to the mobilization of additional technical and financial resources to conduct and step-up continuous research work.

According to the IPCC report, under the influence of global climate change, there is a growing trend of extreme events such as floods and droughts in the future. China has a water deficiency issue: per capita water resources amount to only 2,200 m^3, less than half of the world's average, and the spatial and temporal distribution of water resources is uneven. Climate change will undoubtedly foresee as a serious challenge of China's water resources management.

In April 2009, the Chinese Ministry of Water Resources and the Swiss Federal Ministry of the Environment, Transport, Energy and Information signed a Memorandum of Understanding (MoU). Under this framework, both sides have already carried out a number of projects in the early stage regarding water conservancy technology cooperation, such as the glacial monitoring of the Xinjiang Autonomous Region, the Hanjiang River flood risk assessment, etc. which have achieved satisfactory results.

In order to further strengthen the cooperation between China and Switzerland, in 2013, Switzerland has submitted the "Sino-Swiss Integrated Water Resources Management and Disaster Prevention and Mitigation cooperation proposal" to China, to carry out integrated risk management research of natural disaster prevention and water management under climate change in the Jinsha River Basin.

In response to water security, floods and droughts issues caused by climate change, Switzerland and other European countries recently have put forward some new risk management methodologies, early warning technology and adaptive measures. By learning the integrated risk management methods, considering the hydrological forecasting of snowmelt runoff, and advanced experience of integrated water resources risks management and future climate scenarios from the Swiss team, China's forecast capability of future climate change has been improved and has gained in-depth understanding of its impacts from various aspects. Hence, appropriate adaptive measures and plans could be constructed which will improve China's ability to cope with climate change. In addition to providing hydrological forecasting methodologies and integrated risk management methods, Switzerland has enormous international experiences in emergency response plans, engineering measures and risk management countermeasures related to extreme events that can be shared with China.

The Yangtze River Basin has relatively abundant water resources and it's China's strategic water source area. It's also an important basis of China's sustainable development. The Yangtze River Basin is located in the monsoon climate zone, the spatial and temporal distribution of precipitation is uneven, the water resources system is vulnerable and prone to flood and drought. In the upper reaches of the Yangtze River - Jinsha River, the persistent drought in recent years has brought serious negative impacts and great losses to the local economy and society. At the moment, the understanding of climate change impacts and response measures are inadequate; and relevant water resources management and flood/drought forecasting and early warning capabilities are relatively weak. Therefore, to carry out such comprehensive water resources and risk management in Jinsha River under climate change has significant researching and application value.

Against this background, in 2014, China and Switzerland jointly proposed a new cooperation project "Jinsha River Basin Integrated Water Resources and Risk Management under climate change " (referred to as "JRB Project"). In February 2014, the project kick-off meeting was held in Wuhan and the opening phase contract was signed. On May 12, 2014 in Switzerland, the Chinese Ministry of Water Resources and SDC signed the JRB project cooperation agreement.

Figure 1: Signing ceremony of the JRB Project Cooperation Agreement in Crans-Montana, Switzerland in 2014

After one year of preliminary discussion between the Chinese and Swiss experts, a joint project document was agreed by both sides regarding this project on research objectives, research content, main achievements, organizational management, budget and tasks allocation. It combines the Swiss experience of climate change scenario analysis and risk management together with the Chinese experience in water resource project planning and integrated river basin management. The main purpose of the project is improving the management standard and capability of Yangtze River Basin coping with climate change, as well as setting this project as demonstration project for others. In March 2015, Changjiang Water Resources Commission (CWRC) and EBP performed the JRB Project Kick-off Workshop in Wuhan.

Figure 2: JRB Project Kick-off Ceremony in March 2015

1.2 Project Area Overview

1.2.1 Geographical and Socio-Economic Information

Geographical Location

Jinsha («golden sand») River is located in the upper reaches of the Yangtze River. The origin of the Jinsha River (i.e. Yangtze River) is the Geladandong Snow Mountain of Tanggula Mountain range in Qinghai Province, where it sources from Tuotuo River. From Tuotuo River to Yibin City, Jinsha River stretches to 3’364 km. The basin area is 473’200 km^2, accounting for 26% of the Yangtze River Basin. The average annual flow is 4’750 m^3/s. The main water source is rainfall, groundwater and snowmelt as supplement.

Jinsha River is divided in three reaches (see figure below). From Zhimenda hydrometric station to Shigu town is the so called Upper Reach of Jinsha River, with approximately 965 km length, height difference of 1’720 meters and average slope of 1.78 ‰. From Shigu to Xinshi town (Sichuan Province) it’s called Middle Reach of Jinsha River which has approximately 1’220 km length. From Xinshi town to Yibin town (where Min River flows into Jinsha River), it’s called Lower Reach of Jinsha River which is 106 km long.

Figure 3: Geographical Location of Jinsha River Basin

Figure 4: Jinsha River typical river reaches, referred to localization in Figure 3

Precipitation and Temperature

The average annual precipitation of JRB is approximately 710 mm: the annual precipitation of the lower reaches (Xinshi to Yibin) is approximately 900-1'300 mm. The middle and upper reaches are mountainous canyon regions with an average annual precipitation of 600-800 mm. The annual precipitation in the source area upstream of Zhimenda is less than 200 mm (see figure below).

Precipitation is mainly concentrated from June to October which accounts for about 75-85% of annual precipitation (wet season). The spatial distribution of temperature is similar to precipitation. The overall trend is increasing from upstream towards downstream and from northwest to southeast.

In consequence, the dry season of JRB is from November to May.

The average annual temperature of the JRB area is below 0 ℃ (upper reach), approximately 5 ℃ (middle reach) and above 10 ℃ (lower reach), respectively (see Figure 5 below).

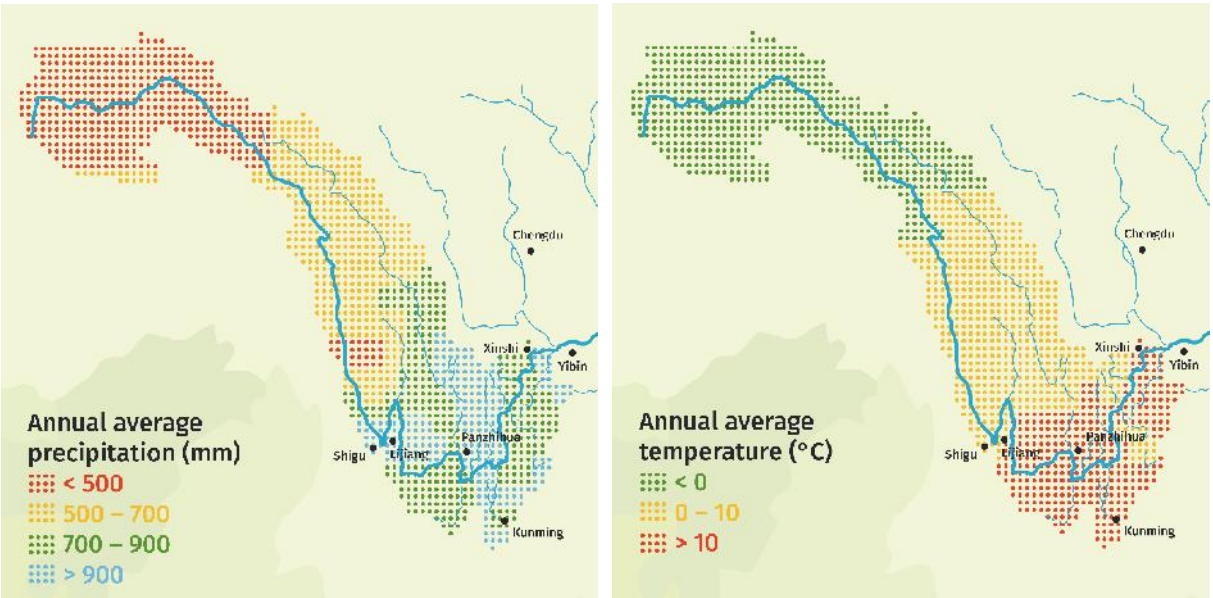

Figure 5: JRB average precipitation and temperature over the years

Runoff and Flood Events

The average water volume over the years for upstream of Shigu is 42.4 billion m^3, Shigu station has an average discharge of 1,343 m^3/s. The average water volume at Pingshan station is 142.8 billion m^3 which accounts for more than one third of the total runoff of upstream of Yichang (Three Gorges Dam) in the Yangtze River.

The Jinsha River flooding along the mainstream is mainly caused by extreme precipitation over a long-time period. Heavy rainfall mainly happens at the middle and lower reaches of Jinsha River. Floods generally occur in late June to mid-October, more frequently from July to September. The duration of the shortest flood is around 10 days, the longest up to 30 days.

Historically, the largest flood event in the middle and lower reaches of the Jinsha River happened 1924. The estimated reoccurrence period is approx.

60 to 120 years. The maximum peak flow at Pingshan station was 36’900 m^3/s.

Dry season runoff accounts for about 25% of the total annual runoff (Pingshan station), the driest season February to April only accounts for about 7% of the total annual runoff.

According to measurement data of the past 60 years, the driest years occurred in 1942 and 1959. The total runoff for Pingshan Station from November 1942 to May 1943 was 28.8 billion m^3, and the total runoff from November 1959 to May 1960 was 29.6 billion m^3. The minimum flow for Pingshan station was 1’060 m^3/s (March 22, 1982) and for Shigu station 310 m^3/s (January 30, 1960).

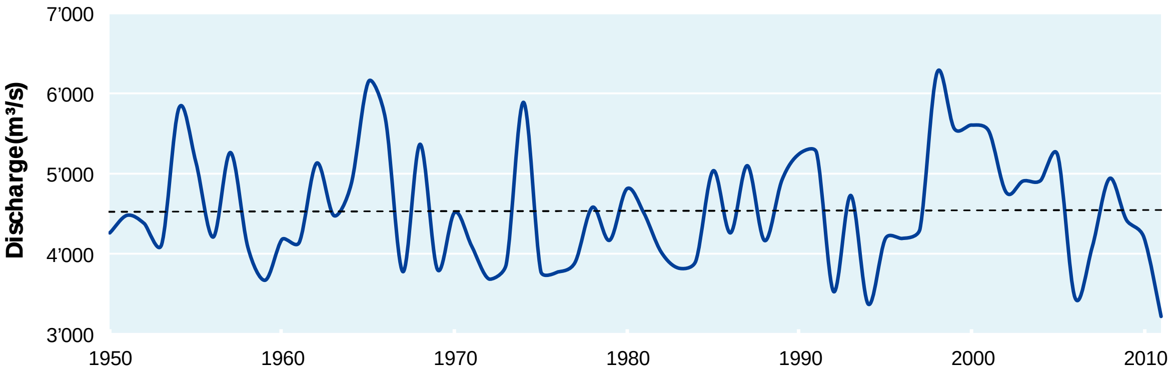

Figure 6: Annual runoff for Pingshan Station Year 1950-2010

Socio-Economic Background

The average population density in the JRB is about 50 per km^2, the population density increases from west to east and from north to south.

In 2010, the total population in the JRB area was about 24 million, of which about 6.6 million in Sichuan Province, about 13.8 million in Yunnan Province and about 0.8 million in Guizhou Province. The population of Qinghai and Tibet is low.

In 2010, the GDP of the whole basin was about CNY 415.7 billion, and the per capita GDP was CNY 17’527.

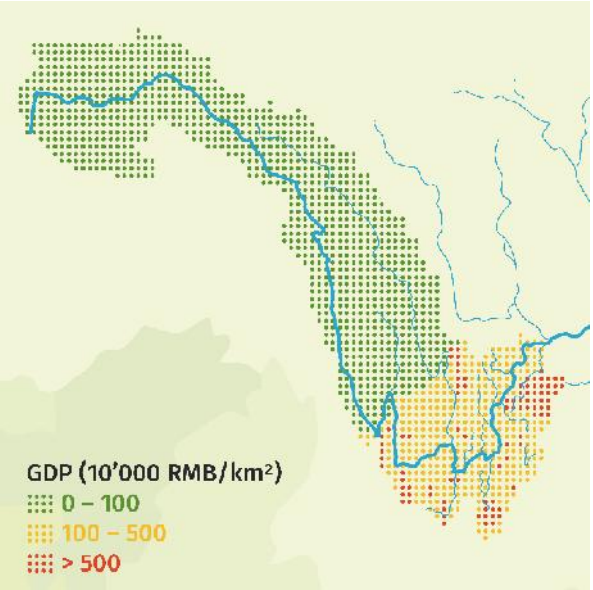

Figure 7: Spatial Distribution of GDP density in JRB in 2010

Hydropower is an important economic sector in the JRB region. Jinsha River is characterized by steep lateral slopes and rapid flow, abundant and stable water resources, large elevation differences between the slopes. The hydraulic energy potential of Jinsha River is enormous with approximately 112 million kilowatts, accounting for about 16.7% of China's hydropower capacity. The potential hydropower capacity which can be developed is about 90 million kilowatts. As the largest hydropower base in China, Jinsha River represents a significant strategic position. There are more than 20 hydropower stations (built or under construction) in the mainstream and tributaries of Jinsha River.

Figure 8: Main hydropower stations in the Jinsha River Basin, Xiangjiaba Hydropower Station (left, under construction), Xiluodu Hydropower Station Dam (right).

Xiangjiaba hydropower station is located in the lower reaches of Jinsha River, 33km away from Yibin City. The construction started in 2006, river interception happened in 2008, the first batch started generating power in 2012 and the construction was completed in 2015. Xiangjiaba is China's third largest hydropower station, after the Three Gorges and Xiluodu located outside JRB region. The total installed capacity is 6.4 million kilowatts, the average annual generating capacity is 30.747 billion KWh.

Xiluodu hydropower station is located in the lower reach of Jinsha River. Construction started in 2005 and the powerplant was put into operation in 2013. The dam is a concrete double-curvature arch dam with an elevation of 610 m, a maximum dam height of 278 m and the top of dam has an arc length of 698 m. The Xiluodu total reservoir capacity is 12.67 billion m^3 with an adjustment capacity of 6.46 billion m^3. Apart from power generation, other benefits of this power station include flood control, sediment barriers and improvement of the downstream shipping conditions. The installed capacity for Xiluodu station is 13.8 million KW. Through the appropriate reservoir management, the sand amount entering the Three Gorges reservoir area can be reduced by 34% of its natural amount. Since the reservoir management can adjust the runoff amount, it can additionally directly improve the downstream shipping conditions.

1.2.2 Selection of JRB and Lijiang

Since JRB is very important for water resources management in China and due to the catchment areas sensitivity to climate change, the Chinese and Swiss decision-makers have selected JRB and its key river sections and main tributaries as the study area (Figure 9) to carry out climate change impact studies. Specific reasons are as follows:

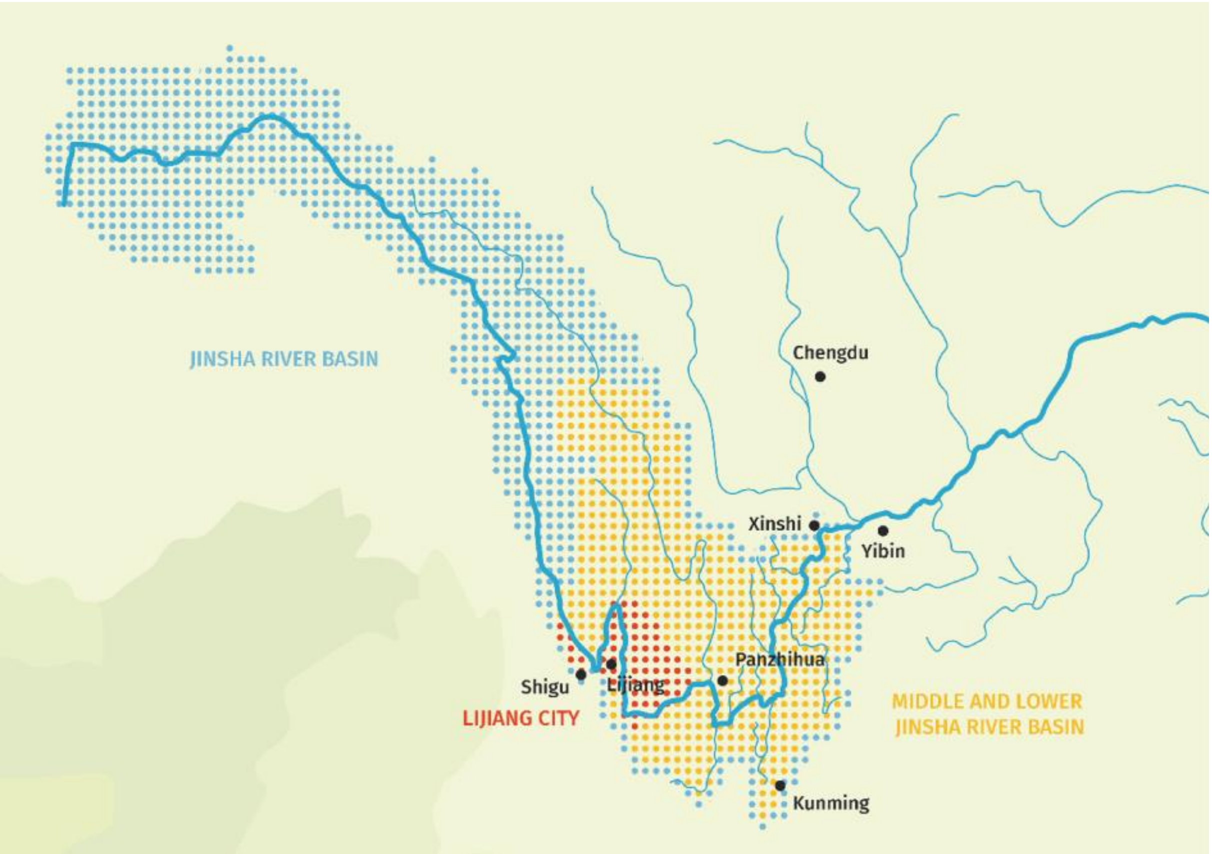

Figure 9: Specific JRB project study area

Motivation for Selection of JRB as the Research Area

1. Large-scale fluctuations in climate and weather within and across the JRB make it more sensitive to climate change. Jinsha River originates in the Qinghai-Tibet Plateau and its eastern edge. The upper reaches

of the source river area are located at an altitude above sea level of more than 5’000m a.s.l., above the alpine climate zone. The annual average temperature is -4.2℃ with large numbers of glaciers and extensive permafrost areas. On the other hand, the lower reach Yibin City has an elevation of 500m a.s.l., with sub-temperate climate and an annual average temperature of 18 ℃.

2. The spatial and temporal distribution of rainfall in JRB is susceptible to global climate change. The average annual precipitation in the upper reaches of the Jinsha River is only about 200mm, while the average annual precipitation in the lower reaches can reach 1200mm.
3. The ecosystems in JRB are fragile and sensitive. Especially, the high mountainous ecosystems in the upper reaches and the source area are particularly affected by climate change.
4. In recent years, there are significant water issues in JRB, especially the frequent drought events in the middle and lower reaches, which seriously affected the local social and economic development as well as ecological conditions.
5. Recently, the impacts of human activities in JRB have been increasing. Many cascade hydropower stations have been built or are under construction in the middle and lower reaches of the main stream and its tributaries.
6. Qinghai-Tibet Plateau, where Jinsha River originates, has a renowned name of “World’s Third Pole”. It’s the origin of the Yangtze River, the Yellow River, Nu River, Lancang River, Brahmaputra, Ganges, Indus and many other rivers. JRB is selected as the research area so that the research results could be used as references for other large rivers.

Motivation for Selection of Lijiang City as Pilot Study Area

To further study the impact of climate change on the economy and society and to study the impact of socio-economic development on water resources management, the project steering committee has selected Lijiang City which is located in the middle reach of the Jinsha River as a pilot study area. Lijiang City, located in the western part of Yunnan Province, is one of China’s historical and cultural cities as well as a world cultural heritage site. Lijiang City includes Lijiang old town with four small districts and eight towns. In 2013, the total population of Lijiang City was 202’400, with the urban population of 169’700 and the rural population of 32’700. Lijiang City is a world-famous tourist destination, the yearly visitor numbers are more than 20 million.

According to Lijiang weather station statistics, the average annual rainfall is 972mm and the average annual temperature 12.6℃. Lijiang City is densely populated and it belongs to the water scarcity areas. Lijiang City has an average amount of water resources of 160 million m^3, water resources per capita is 838 m^3, which is only 18% of the average per capita amount in Yunnan Province. This area has serious water shortages.

Since 2010, due to the impact of climate change and human activities, Lijiang City suffered continuous drought issues, with regional fast economic and social development, the total water demand has been increased. There has been water shortage, the Black Dragon pond water has been cut off, river network system shrinking and other water crisis occurred. These issues have already aroused the utmost attention both nationally and internationally.

1.2.3 Study Areas

According to the overall arrangement and research contents of the JRB project, the study area is structured in three areas with different scopes, as shown in Figure 9:

1. Entire JRB (area of 473'200 km^2): focus on climate change scenarios as well as river basin meteorological and hydrological factors which will affect the changing trend;
2. Lijiang City (area of 20'600 km^2): focus mainly on the impact of climate change on local water resources and its countermeasures, and on setting up terrestrial monitoring station on Yulong Snow Mountain to observe the changes of glaciers and snow cover.
3. Middle and lower reaches of the Jinsha River (Shigu to Yibin, with a length of approximately 1'071 km): focus on the impact of climate change on the runoff process, flood control and water supply as well as its countermeasures. Additionally, research on the impact of climate change on the aquatic ecosystem (specific fish species) is conducted in this area.

1.3 Project Organization and Partners

The project organization mainly includes the Project Steering Committee, the Project Leading Unit and the Project Implementation Unit. Their responsibilities are shown in Figure 10. The Swiss and Chinese teams work closely together at the project organization level to jointly promote the Sino-Swiss cooperation project – «The Jinsha River Basin Water Resources and Risk Management under Climate Change».

The project organization consists of the following three levels and their corresponding roles. As a Sino-Swiss cooperation project, Swiss and Chinese partners are involved in the project with close collaboration on all project organizational levels.

STEERING COMMITTEE

Steering and funding,
reports to Sino-Swiss MoU Group

- Ministry of Water Resources China MWRC
- Swiss Agency for Development and Cooperation SDC,
  Swiss Embassy

PROJECT LEADING UNIT

Review and monitoring,
technical guidance

- Swiss Agency for Development and Cooperation SDC
- Changjiang Water Resources Commission CWRC

PROJECT IMPLEMENTATION UNIT

Project management,
coordination and implementation

Swiss Partners

- EBP
- Geotest
- Hydrique

- Crealp
- Geopraevent
- Peter Fishconsulting
- Sje Engineering
- MFB-GeoConsulting

Chinese Partners

- Changjiang River Scientific Research Institute CRSRI
- Changjiang Institute of Survey, Planning, Design and Research CISPDR
- Bureau of Hydrology BOH
- Institute of Hydro-Ecology IHE
- Nanjing Hydraulic Research Institute NHRI
- Cold and Arid Regions Environmental and Engineering Research Institute CAREERI

Figure 10: Project organizational chart and functions including main Swiss and Chinese project partners

2. Project Objectives

The long-term project objectives consist of the improvement of the integrated water resources and risk management framework (IWRM) for JRB under conditions of changing climate and social-economic development. Furthermore, IWRM shall meet the strategic development needs of the CWRC, aiming at effectively protecting life and assets, ensuring water security of the region, contributing to the sustainable development of the Chinese economy, and to a source of learning for global climate change discussions.

The objectives of the project phase 2015 – 2018 are to develop methods, instruments and models to enhance the water management practices for the JRB and to enable adaptation strategies and measures to climate and socio-economic change. The methods and models may be tested and demonstrated through applications in different study areas (see Chapter 1.2.3) and shall fundamentally contribute to the following Outcomes:

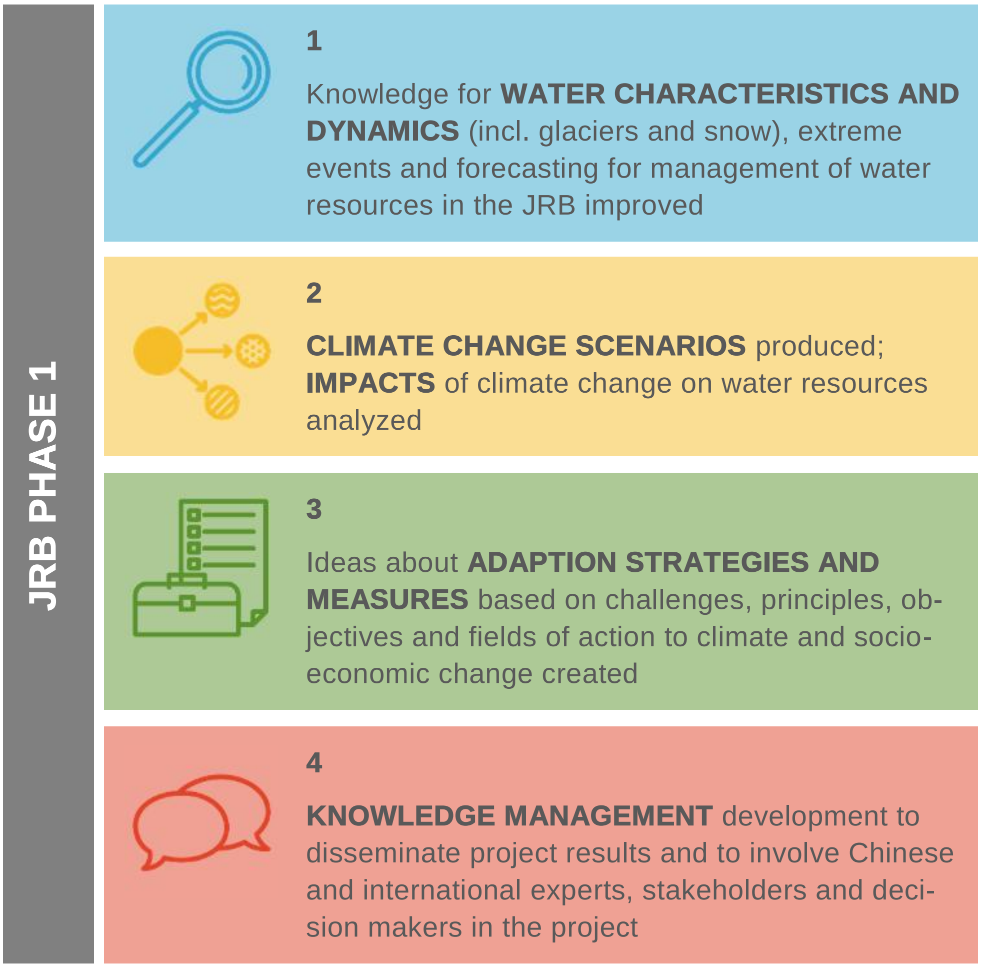

Figure 11: JRB Phase 1 aims at building the fundamental basis towards the long-term vision of IWRM.

One of the major goals of the JRB project is to analyse the evidence that climate change already has or will have a significant impact on the water ressources of JRB. This is done in two different ways. First, past meteorological and hydrological data is screened and analyzed whether patterns of climate change are already visible. Second, global circulation models (GCMs) from well-known universities and institutions world-wide predicting future trends in temperature and precipitation are used to derive climate change scenarios, which are needed to analyse the expected impacts of climate change. Since predictions about the future climate contain significant uncertainties, an uncertainty analysis is included whenever future impacts of climate change are estimated.

3. Approach

This project combines advanced multidisciplinary studies and technologies from hydrology, water resources, meteorology, climate change etc., with observation and measurements, numerical simulation and modern GIS technology, following holistic processes of “data collection - model building – trend analysis – impact analysis – adaptation measures” to carry out integrated research activities.

The following Figure 12 outlines in details these processes, as part of the overall JRB outcomes 1 Water Characteristics and Dynamics, 2 Climate change scenarios and impact analysis and 3 Adaptation strategies and measures (according to Chapter 2).

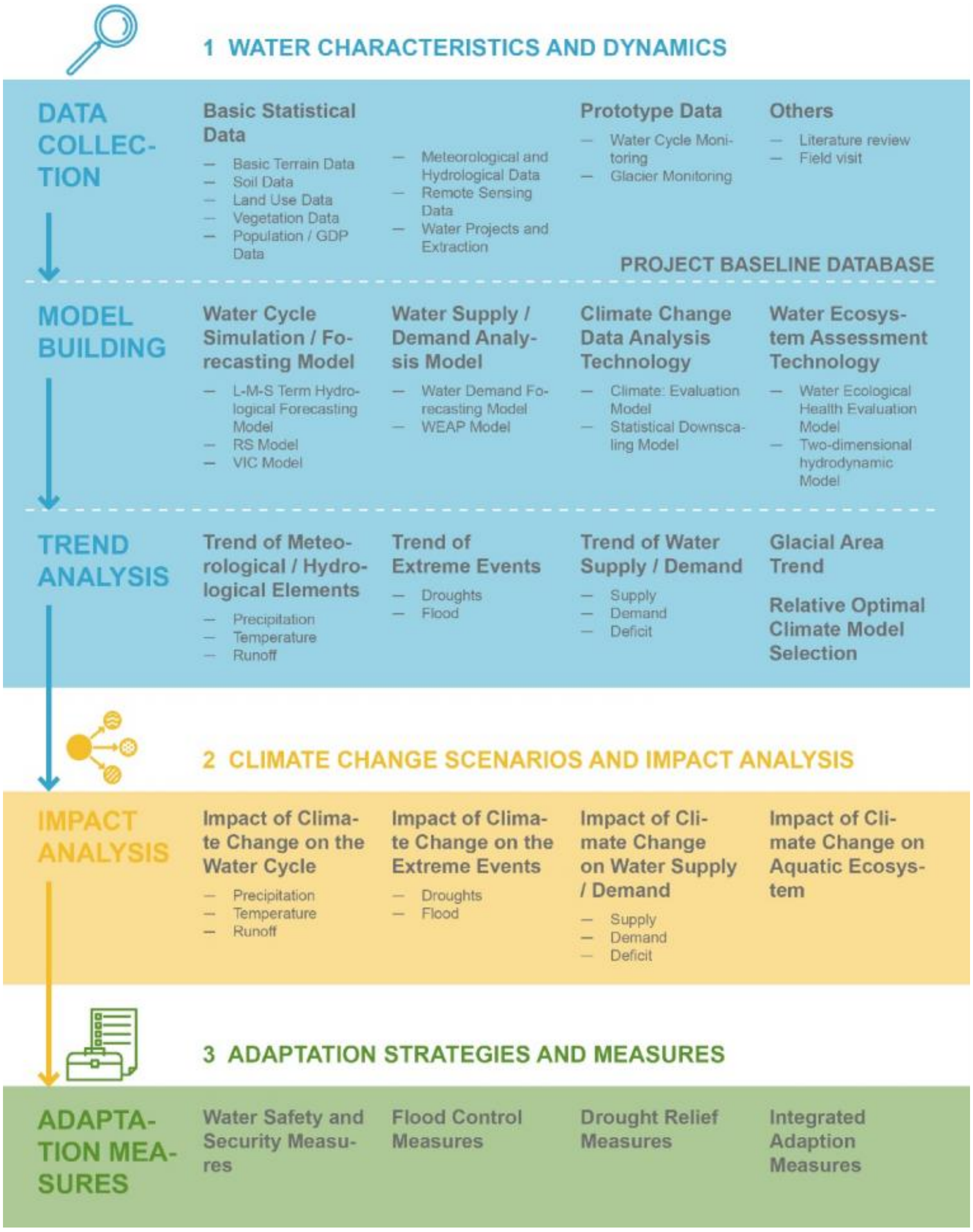

Figure 12: JRB Project holistic processes in the framework of overall JRB outcomes

1 Water Characteristics and Dynamics

Data Collection mainly includes observation of gauging stations (including hydrology, meteorology and ecosystem monitoring), also satellite remote sensing observation, basic geographic information, statistics of social and economic factors, literature reviews and field investigations through multi-scale, -dimension and data source methodologies. Based on this, the information is effectively pre-processed to provide data support for the follow-up research work.

Model Building consists of the constructing the hydro-meteorological forecasting model HMFM (RS model), water allocation model (WEAP model), climate scenario evaluation model, statistical climate scenario downscaling model, aquatic ecosystem fish habitat model (incl. 2D hydrodynamic model) to provide technical support for understanding of historical evolution patterns and forecasting of future trends.

Trend Analysis: Based on the historical data and established models, the historical trends of the key water cycle factors such as precipitation, temperature and runoff in JRB have been identified; the changes and characteristics of extreme hydrological events (such as flood and drought) were evaluated; and analysis of the water demand and supply, as well as water deficits of Lijiang City; based on remote sensing data and field observations, analysis of Yulong Snow Mountain glacier characteristics and changes.

2 Climate Change Scenarios and Impact Analysis

Impact Analysis: Based on the climate change scenario and forecast datasets, the implemented models have been able to predict the key water cycle elements (precipitation, temperature, runoff, etc.), extreme hydrological events (floods, droughts), the aquatic ecosystem in JRB, and the water supply and demand relationship in Lijiang City under future climate change. These results are the scientific basis for the formulation of comprehensive adaptation measures.

3 Adaptation Strategies and Measures

Adaptation Measures: Based on the results of the analysis of future climate change impacts, by evaluating water security, flood control and drought relief measures, etc., exemplary adaptation measures for both the pilot areas and the whole JRB were formulated and assessed.

4. Research Topics and Results

Based on the JRB Project, holistic processes in the framework of overall JRB outcomes (see previous chapters), the following chapter gives a systematic overview of the key topics of research, the results provided, the products (tools, methods, models) elaborated as well as interactions and synergies between them. At the end of each topic, the main results are summarized. More technical details to each topic is given in separate Output Reports.

4.1 Water Characteristics and Dynamics

4.1.1 Historical Extreme Events

Water-related natural extreme events can strongly influence water resource management. The occurrence, magnitude and consequences of such events have to be analyzed and understood in order to create a sound basis for a thorough planning of measures and the long-term development of the region. For this, a standardized web-based natural hazard event registration platform for the Jinsha River Region was developed (http://jinsha.geomaps.ch). It can be used for both event data registration or browsing registered events. Collected data and spatial information for about 60 events of different natural hazard processes (floods, droughts, debris flows and landslides) have so far been registered on this platform, including information sources, affected areas, duration, spatial and temporal distribution, damage and financial loss, data quality and uncertainties.

Figure 13: The upper Yangtze River (Jinsha River) is almost dammed by a debris flow deposit from the Xiaojiang River

Extreme drought events hit large areas, and some of the registered extreme events have affected the entire lower and middle JRB (see Chapter 4.3). Also flood events can affect long stretches of Jinsha River and/or its tributaries. The area affected by significant flood damage to people or economic losses, however, is more concentrated along certain river sections. The registered debris flow events are concentrated at some specific spots in JRB and affect relatively small areas with their direct impacts. Landslide events with related damming of the rivers are located all over JRB, and they too usually only affect a restricted area. However, catastrophic failures of such landslide dams have occasionally caused severe flooding downstream as well as the loss of many lives.

Results Summary

The newly developed **standardized event registration platform** proved to be beneficial to record, visualize and analyze heterogeneous event data sets. It allows data input by different stakeholders using various archives and indicating the uncertainties of each dataset. Main characteristics like affected people and areas and economic damage have been registered for 32 floods, 16 droughts, 10 debris flow and 4 landslide events.

The largest registered extreme **flood events** occurred between 1860 and 1924; no events reached the extreme flood classification since then. The 2005 flood event is the most recent large event, with high water levels and impacts particularly in the middle reach of JRB.

A clustering of severe and continuous **droughts** comparable to the drought episodes around 1940 was observed from 2009 to 2014. A further accumulation of drought events happened in the 1980s.

Due to the absence of uniform criteria for recording extreme events and because of incomplete data – in particular for drought events before 1980 – it is difficult to make reliable statements on trends in frequency and extent of extreme events.

4.1.2 Analysis of Hydro-Meteorological Characteristics

Hydro-meteorological data for the region from the last 50 years were collected and analyzed to gain a better understanding of the water characteristics of JRB in the past. Data from 45 meteorological stations (daily precipitation, minimum, average and maximum temperature) and 5 hydrological stations (daily discharge) was systematically analyzed.

A universal tool for hydro-meteorological data analysis was specifically developed for this project - HydroAnalysis R-package - which allows for an easy analysis of basic statistic parameters, including frequency and intensity of events and their trends.

The mean temperature shows a significant upward trend at almost all stations, with an average increase of 0.2°C within 10 years. For average precipitation, most stations in the upper and middle reach of JRB show an increase, whereas most stations in the lower JRB show no clear trend. However only few stations, most of them in the uppermost part of JRB, show a significant change in precipitation (significant being defined here as a probability of 95% that the trend is not purely accidental). However, because the natural variability of precipitation at specific location is generally very big, it is common that changes in past precipitation are not significant at the 95% significance level.

As far as discharge is concerned, the Huatan station shows a significant increasing trend. As is generally the case, no significant trends in peak discharge can be observed.

In general, no significant trend in the duration, magnitude and intensity of short, medium and long-term drought events was identified. However, a certain increasing trend in the number of rainy days per year has been detected for some stations in the upper part of JRB, and a decreasing trend in some stations in the lower part, which is in line with trends in total yearly precipitation.

Figure 14: The legendary first bend of Yangtze River near Shigu in Yunnan Province

Although not all station data was available to analyse discharge trends, sufficient data could be used in the project so that the results can be considered as robust.

The results of this research helped to make a plausibility check on the climate change projections and the respective trends on the climate variables, which are often already visible in the past. Evidence about climate change in the data of the past 50 years can be summarized as follows:

- A significant increase in temperature can clearly be seen.
- Although precipitation trends are in general not significant at specific sites (at least not at the 95% significance level), the great majority of stations, most of them in the upper and middle part of JRB, show an increase in average precipitation. Therefore, indications of an increase in average precipitation for the major part of JRB are stronger than indications to the contrary.
- As is generally the case, no clear trends can be seen for extreme precipitation events.

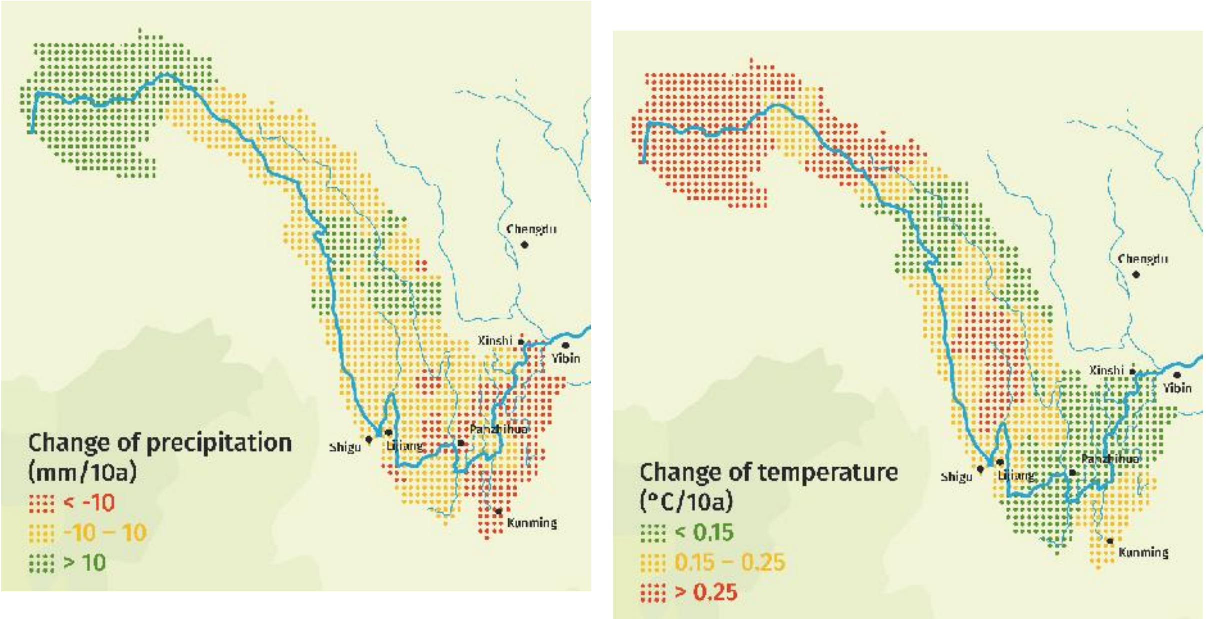

Figure 15: Spatial distribution of precipitation and temperature change trend in Jinsha River Basin from 1961 to 2010

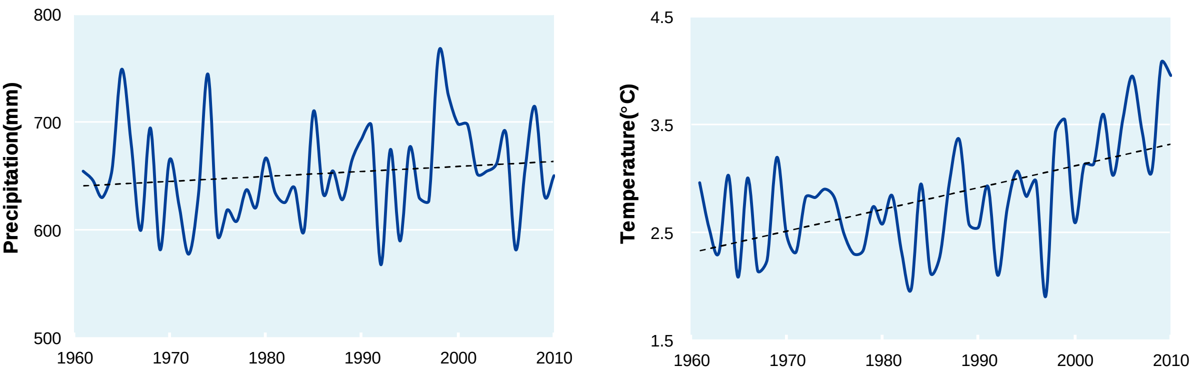

Figure 16: Precipitation and temperature in Jinsha River Basin from 1961 to 2010

Results Summary

The **hydro-meteorological data analysis tool** "HydroAnalysis R-package", which was specifically developed for this study, allows an - analysis of basic statistic parameters including trends.

The **mean temperature** shows a significant upward trend at almost all stations, with an **average increase of 0.2°C within 10 years**. In the past 50 years, average **precipitation** in the upper and middle part of JRB increased, although this increase is not significant at individual stations in most cases. Nevertheless, the overall data suggest that average precipitation has increased for the largest part of JRB.

Furthermore, no significant trends in the duration, magnitude or intensity of **drought events** could be identified. The same is true for peak discharge.

4.1.3 Glacier, Snow Cover and Snow Melt Monitoring

Glaciers and seasonal snow cover in JRB are important components of the water cycle. Therefore, the investigation of their current situation and changes is of high relevance, especially at the local level in mountainous regions.

Terrestrial glacier monitoring and satellite-based snow cover monitoring will improve the understanding of the status and dynamics of different factors such as patterns of snow cover distribution, snow volume, snow and glacier melt, glacier ice-flow dynamics, droughts, floods, and their impacts on the water resources in the region.

To increase climate change detection capability, enhanced monitoring equipment for Yulong Snow Mountain was designed and implemented. By using this equipment, the glacier monitoring capability was significantly improved. Operation of the automatic glacier monitoring station greatly reduced the manual measurement workload and improved monitoring efficiency.

In addition, satellite remote sensing was used to monitor the snow cover patterns and their regional distribution. For future climate change modeling, remote sensing delivers indispensable information. The studies have shown significant deviations from the common assumption of an evenly distributed snow cover.

Furthermore, the Snowmelt Runoff Model (SRM) was applied to analyze the relationship between snow covered area and runoff in the headwater region of Yangtze River during the different representative years. It became clear that contribution of snowmelt to runoff is small but that snow cover variations in different altitudinal and regional zones may have significant influence on the climate.

The two monitoring systems are important tools for the research teams (CRSRI and CAREERI) to record changes in glacier and snow melt, snow cover distribution, and to deliver true evidence for the public to understand climate change.

Figure 17: Enhanced glacier monitoring equipment for Yulong Snow Mountain was installed on Yulong Snow Mountain to increase the detection capability of climate change

Results Summary

The **glacier terrestrial observation station** established in this project provides basic data support for understanding the impact of climate change on glacier melting and runoff. For the first time, glacier changes on Yulong Snow Mountain are visualized **by real-time monitoring**.

Based on the satellite remote sensing data, the results of the **snowmelt runoff model** showed that the **contribution of snowmelt to runoff** in the lower part of Jinsha River is **insignificant**. However, snow cover variations in different altitudinal and regional zones may have significant influence on the climate and on the runoff in small rivers.

Both monitoring systems are important tools to record changes in glacier and snow melt and to **visualize climate change to raise public awareness**.

4.1.4 Predict Runoff, Prevent Flooding: Hydro-Meteorological Forecast Model

JRB is a very large area with complex climate and terrain. Numerous large reservoirs exist and new ones will be built along Jinsha River and some of its major tributaries, which are mainly used for hydropower production, but can also contribute to flood control and irrigation. Large floods occur frequently in JRB, leading to inundations in the downstream area of the basin near Yibin City. For these reasons, a powerful and reliable hydro-meteorological forecast model (HMFM) is needed for reservoir management during floods or droughts, to operate a warning system for the population and to provide decision-making support.

Figure 18: Hydro-meteorological gauging station at Er Lake near Dali, as part of the forecasting system

As part of the analysis of the water characteristics of the region and with respect to the runoff prediction and flood prevention requirements, a HMFM has been elaborated in which the large reservoirs are integrated.

The HMFM has been incorporated into the existing forecasting system of CWRC. The results can provide an additional data reference and decision-making basis for CWRC to operate flood prevention, and hence enhance the commission’s capability in terms of runoff prediction and flood prevention management.

Data from almost 400 rainfall gauging stations, over 70 discharge gauging stations and a dozen large reservoirs were included in the model. Real-time transfer of weather forecasting data from the Bureau of Hydrology (BOH) at CWRC to the database has been programmed. The so-called Routing System (RS) model is used for the entire Jinsha River, covering more than fifty forecasting points.

Runoff forecasts in different regions of JRB are therefore possible, and operation of the reservoirs included can be optimized. Results from model runs have also been used to estimate impacts of climate change on the future discharge and hydropower production in the region.

Through real-time data acquisition, automatic parameter calibration and the simulation of plausible reservoir management rules, the quality of forecasts has been further improved. The model can produce results that can directly be integrated within the BOH visualization. The system not only provides real-time forecasts four times a day, for lead times ranging from 1 day to 10 days, but also long–term runoff predictions are available based on corresponding rainfall predictions provided by other models or tools inputs. Additionally, through training, the experts from BOH have mastered the operation and maintenance skills of the forecast system.

For the future, it is necessary that BOH experts integrate the simulation model maintenance into their daily tasks, focusing on a detailed database control. This is necessary because of the complexity of data transfer processes.

With a consequent system control and maintenance, a strong added value in terms of decision making support will be obtained with the use of the RS model due to the integration of meteorological scenarios and reservoir management.

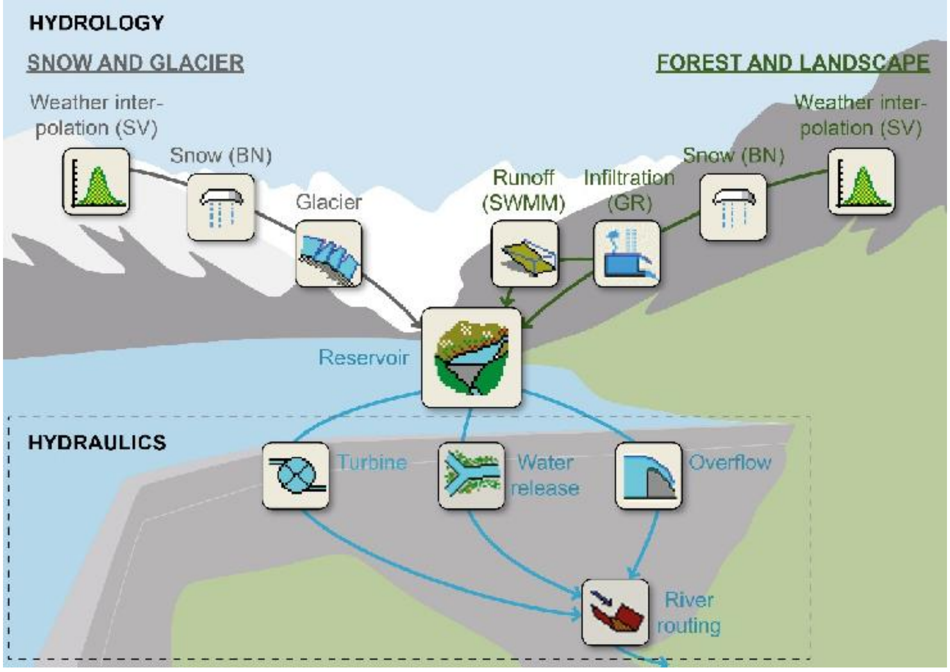

Figure 19: Establishment of RS Model for Jinsha River Basin

Results Summary

A hydro-meteorological forecasting model (HMFM) suitable for JRB with integrated large reservoirs has been developed, which allows **hydrological forecasting** for more than fifty locations all over the JRB **based on weather predictions on three time-scales**. The model is incorporated into the existing hydrological forecasting system of BOH. Additionally, BOH experts have been **trained** to operate and maintain the forecasting system.

The new tool supports **decision making** and contributes to enhance **flood alert and reservoir regulation** which allows for better flood control and to optimize water resources management for irrigation and hydropower generation.

4.2 Climate Change Scenarios and Impact Assessment

The impacts of climate change on water resources, river discharge, water-related extreme events and aquatic ecosystems in JRB have been analyzed based on climate change scenarios for temperature and precipitation. Weather and discharge data analysed previously (see chapter 4.1.2) served as a baseline describing the present climate.

4.2.1 Climate Change Scenarios

Scenarios describing expected climate change in JRB are of critical importance to understand how climate change affects water resources, river discharge and extreme events such as floods and droughts.

Climate change critically depends on asumptions regarding the future emission of greenhouse gases. Four different emission scenarios are considered in todays literature: RCP 2.6, RCP 4.5, RCP 6 and RCP 8.5. RCP 2.6 assumes peak emissions between 2010 and 2020, which doesn't fit current emission data. RCP 8.5 is the scenario that corresponds most closely to the current emission trajectory.

Considering other uncertainties in GCMs, leading to a significant overlap of predictions based on RCP 4.5, RCP 6 and RCP 8.5, to include RCP 6 was of limited benefit. Therefore, the moderate RCP 4.5 and the most extreme RCP 8.5 emission scenarios have been selected, assuming that the most probable emission scenario is laying somewhere in between. The uncertainties regarding future greenhouse gas emissions are well covered with this selection.

Changes in temperature and precipitation were analysed based on results of 36 CMIP5 general circulation models (GCMs) published by well-known climate change research institutions world-wide. Based on their past performance for JRB, a subset of independent GCMs covering the inherent uncertainties was chosen to be most suitable for JRB project.

Based on the predictions of those GCMs for the two emission scenarios RCP 4.5 and RCP 8.5 and two statistical downscaling methods, a set of 24 climate change scenarios for daily temperature and precipitation was elaborated on a grid covering the entire JRB, with 8 scenarios covering the near future (2021-2050) and 16 scenarios covering the far future (2070-2099). The use of several climate scenarios for both the near and the far future forms the basis for a subsequent uncertainty analysis regarding the impacts of climate change.

For the downstream part of JRB, a temperature rise of 1 – 2°C in the near future and 1.5 – 5°C in the far future is expected (compared to the 1981 – 2010 baseline). Whereas the trend towards higher temperatures is unambiguous, the trend in average precipitation is more uncertain. Most climate change scenarios show an increase in precipitation for the upstream and middle part of JRB, whereas the change for the downstream part of the region is uncertain. This corresponds to current trends, which underlines the plausibility of the climate change forecasts (see Chapter 4.1.2).

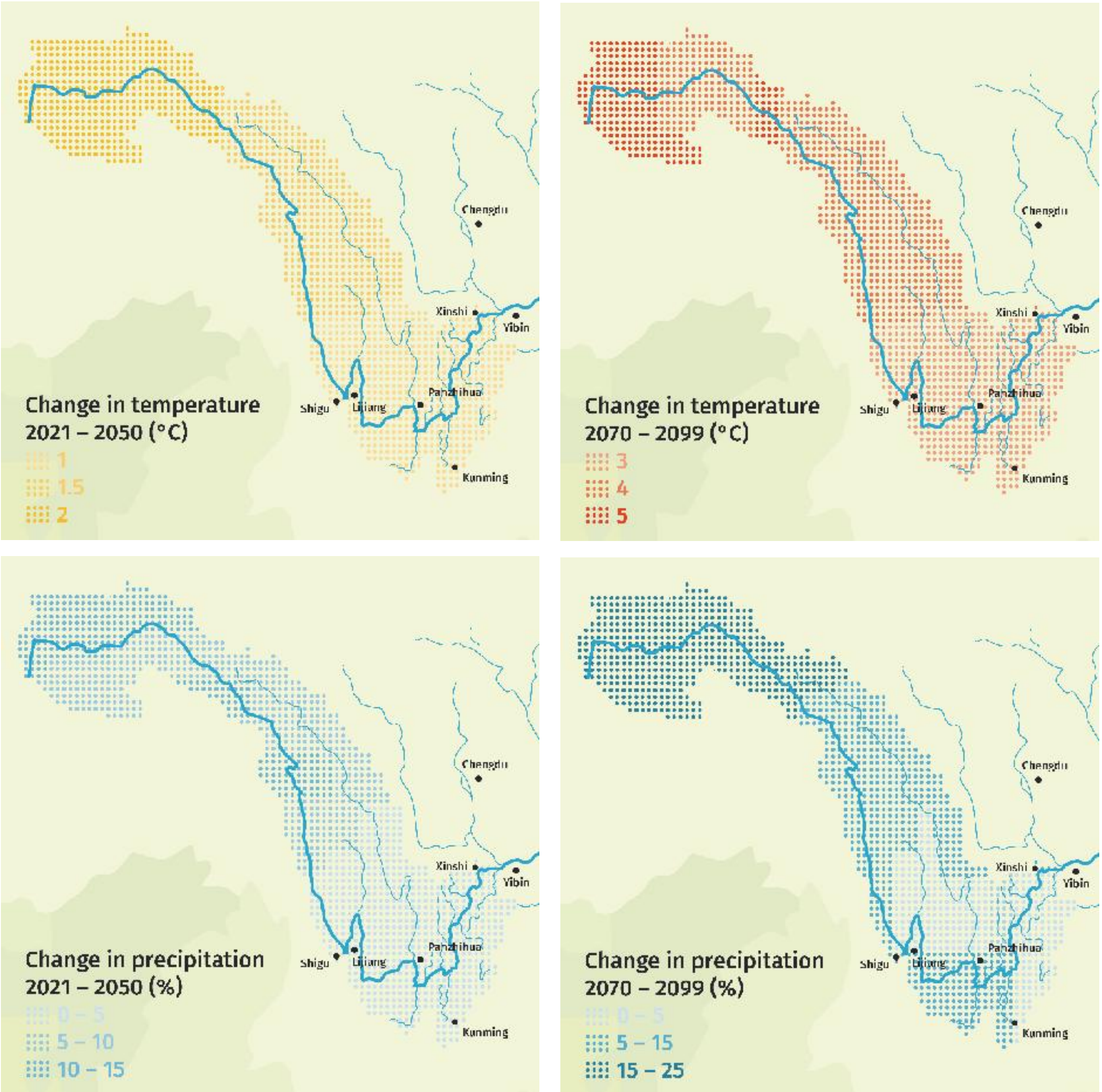

Figure 20: Median of temperature and precipitation change under multiple climate change scenarios for the near and the far future.

Results Summary

The scenarios RCP 4.5 and 8.5 were selected to represent the future greenhouse gas emissions and their uncertainties. Furthermore, a set of GCMs, mainly based on their performance to model past climate in JRB, was selected to be representative to predict expected future trends.

From this, a set of 8 **climate change scenarios** for the expected daily temperature and precipitation in the near future (2021-2050) and 16 in the far future (2070-2099) was elaborated.

For the downstream part of JRB, a **temperature rise of 1 – 2°C in the near future and 1.5 – 5°C in the far future** is expected. The corresponding values are slightly higher towards the North. Precipitation trends are more uncertain. Most climate change scenarios show an **increase in precipitation** for the upstream and middle part of JRB, whereas the change for the downstream part is uncertain.

The climate scenarios can be used in further studies where time series of daily temperature and precipitation data for JRB with the correct statistics are needed.

4.2.2 Climate Change Impact Assessment

For the entire JRB, the impacts of climate change, characterized by the 24 climate change scenarios, on water supply and demand, river discharge, water-related extreme events as well as on sectors like hydropower (electricity production), agriculture (e.g. crop suitability) and aquatic ecosystems (e.g. fish habitat quality) were analyzed. Additionally, the impacts on industry, residential areas/tourism and agriculture for the Lijiang area were studied by analyzing water balance, identifying water deficits and considering future socio-economic trends.

Opportunities and challenges due to climate change have been identified and formed the basis for JRB exemplary adaptation measures (see following chapter). Based on a stakeholder system analysis, the list of provincial and municipal stakeholder organizations was drafted and the approach for stakeholder participation and feedback determined.

Impact assessment for water supply and demand

The impact on water supply and demand in Lijiang City was evaluated using a water allocation model (Water Evaluation and Planning Model, WEAP). The results show – among others – that the future demand for agricultural irrigation water is expected to increase by 3% (near future) to 7% (far future); due to urbanization and an increase in tourism, domestic water demand is expected to double. The assessment shows that Lijiang is already suffering from water scarcity today. And the water supply and demand situation will become more critical in the future, especially during the dry season.

Figure 21: Sequence of the water supply channel and irrigation system in Lijiang.

Impact assessment for discharge and on electricity production at hydropower stations

Due to higher mean precipitation in the upstream and middle part of JRB, average yearly discharge is expected to increase by about 5% along the whole Jinsha River, with slightly higher values for the wet season from May to October. Almost all climate scenarios show the same trend, so the uncertainty is limited. The trend for the dry season alone is much more uncertain, with both increasing and decreasing flow depending on the specific location.

Higher runoff leads to more power generated at the hydropower stations. The simulation shows, however, that the amount of electricity generated will only increase by about 1.3% in the near and 2.6% in the far future. This is due to the limited production capacity during the wet season. Without increasing the turbine capacity, the percentage of flow usable for electricity production will decrease.

Impact assessment for crop cultivation

The impact of climate change on the size of the areas with suitable climate to cultivate the most important crops common in JRB has been estimated for both rain-fed and irrigated cultivation. The approach is focusing only on the expected changes due to average temperature and – for rainfed crops – average precipitation. With the increase of temperature and precipitation, the area suitable for crop cultivation will raise in most cases. For example, the suitable area for growing wheat (rain-fed and non-irrigated) will expand by 1 - 1.5° towards the north or 300 m higher up above sea level.

Impact assessment for extreme events

The frequency and intensity of different types of extreme flood and drought events in the JRB under 24 different climate scenarios have been analyzed. For river flood and hydrological drought, the results are based on RS model runs, which provided daily runoff for 30-year periods in the near and far future.

The results indicate that for mainstream river floods of a given occurrence rate, flood intensity, as measured by peak daily discharge or total flood volume on time scales of a few days, is expected to increase significantly. These results should draw attention to further review the design of flood capacity measures and the management of events, where given thresholds (e.g. warning levels) are exceeded.

Due to the rising number of days with intense rain, flash floods in tributary areas are expected to occur more frequently in the future, creating more damage.

During the dry season, increasing evaporation due to higher temperature dominates possible, but highly uncertain changes in precipitation patterns. Therefore, the frequency of hydrological drought events for a given, very low water level will increase. Regarding agricultural drought[1], where the so called Standardized Supply-Demand Water Index was used, it is shown that there can be a significant increase in crop water demand due to rising evapotranspiration, which could, if irrigation water is scarce, lead to a higher frequency, intensity and duration of agricultural drought events. There is, however, a big uncertainty regarding the impact of increased atmospheric CO_2 concentration on the water demand by plants to produce a given amount of biomass. Therefore, the impacts of climate change on crop yield and irrigation demand is highly uncertain and needs being analysed in more depth.

Impact assessment on aquatic ecosystems

Cold water fish species which are widely distributed in the Jinsha River will be increasingly under pressure due to climate change. The current condition of the aquatic ecosystem in the Jinsha River has been analyzed to gain an overview on the fish, phytoplankton, zooplankton, zoobenthos in Jinsha River. The results provide detailed information on the diversity of aquatic organisms, current ecosystem health levels and the vulnerability of the aquatic ecosystem, indicating urgent needs for ecosystem protection and restoration.

To further study the impact of climate change and hydropower operation on fish habitat, a habitat model for two representative fish species in two life stages was established for a river reach of 10 km near Panzhihua (see location of the city in Figure 3. The water temperature rise is regarded to be the most important factor caused by climate change affecting cold-water fish habitat by shortening their spawning period. The interactions among different species will induce variations into the fish community structure and eventually result in many ecological responses such as alterations in species distributions, reduced biodiversity, invasion of alien species and food web structure.

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[1] An agricultural drought is considered to have set in when the soil moisture availability to plants has dropped to such a level that it adversely affects the crop yield and hence agricultural profitability.

Furthermore, the combined effects of hydropower stations such as impoundment, alteration of hydrological regimes, blocking effect and hypolimnetic discharges will accelerate the ecosystem's degradation. The restoration of longitudinal connectivity (upstream and downstream direction) should be a high priority of rehabilitation works in these systems to make essential spawning habitat accessible. As long as the mainstream of the Jinsha River is blocked by many large dams, tributaries such as the Heishui River, Xining River and Xixi River are particularly important for fish habitat protection.

Figure 22: Target fish species Coreius guichenoti (left) and Jinshaia sinensis for the impact assessment study

Results Summary

The findings of the impact assessment based on future climate change scenarios can be summarized as follows:

The future **water supply and demand** in Lijiang City will become more critical, especially during the dry season. The future water demand for agricultural irrigation, which dominates water use, is expected to increase by 3% (near future) to 7% (far future). Due to urbanization and an increase in tourism, domestic water demand is expected to double.

Average annual **runoff** as well as runoff during the wet season are expected to increase significantly in the JRB main stream. Due to limited turbine capacity, hydropower production will not increase proportionally. The trend for runoff during the dry season is highly uncertain.

With the increase of yearly precipitation and temperature in the JRB, the **area suitable for the cultivation of important crops** may raise, shifting further north and to higher altitudes.

Intensity of **extreme river and flash floods** of a given return period are expected to increase or – equivalently – floods of a given intensity are expected to happen more frequently. These results are a direct consequence of more intense rainfall events due to rising temperature and higher water content of the atmosphere. Although difficult to capture statistically in the past despite ongoing climate change, experts agree that extreme precipitation events will become more frequent in many areas around the world.

Due to higher evaporation, **hydrological droughts** are expected to become more frequent during the dry season. The expected increase in frequency, intensity and duration of **agricultural droughts** is subject to great uncertainty.

Rising water temperature caused by climate change is regarded as the most important factor affecting **cold-water fish habitat** by shortening their spawning period. However, hydroelectric power plants have a greater impact on fish ecology than climate change because dams block fish migration paths to their optimal habitats in various phases of their life-cycle. Therefore, the restoration of **longitudinal connectivity** and **conservation of habitat** in the Jinsha River's tributaries should have high priority of rehabilitation work.

The **uncertainties in the predicted impacts** of climate change are shown by plotting individual results for every single climate scenario.

4.3 Adaptation Strategies and Measures

A literature research on international and Chinese experiences in adapting to climate change in mountain regions, an institutional analysis for China, as well as an outline of long-term climate change adaptation strategies and exemplary measures on water resources management, flood control and drought relief have been elaborated.

4.3.1 Long-term Climate Change Adaptation Strategy

A long-term adaptation strategy includes the methodologic framework of the adaptation strategy that contains the overall objectives of the adaptation activities, the political and institutional framework, capacity building and sensitization as well as the concrete adaptation measures. The embedding in existing strategies and policies is an important aspect to be considered in the elaboration of the long-term adaptation strategy. To guarantee a continuous improvement and optimization of the adaptation activities, a periodic review of the adaptation plan is needed.

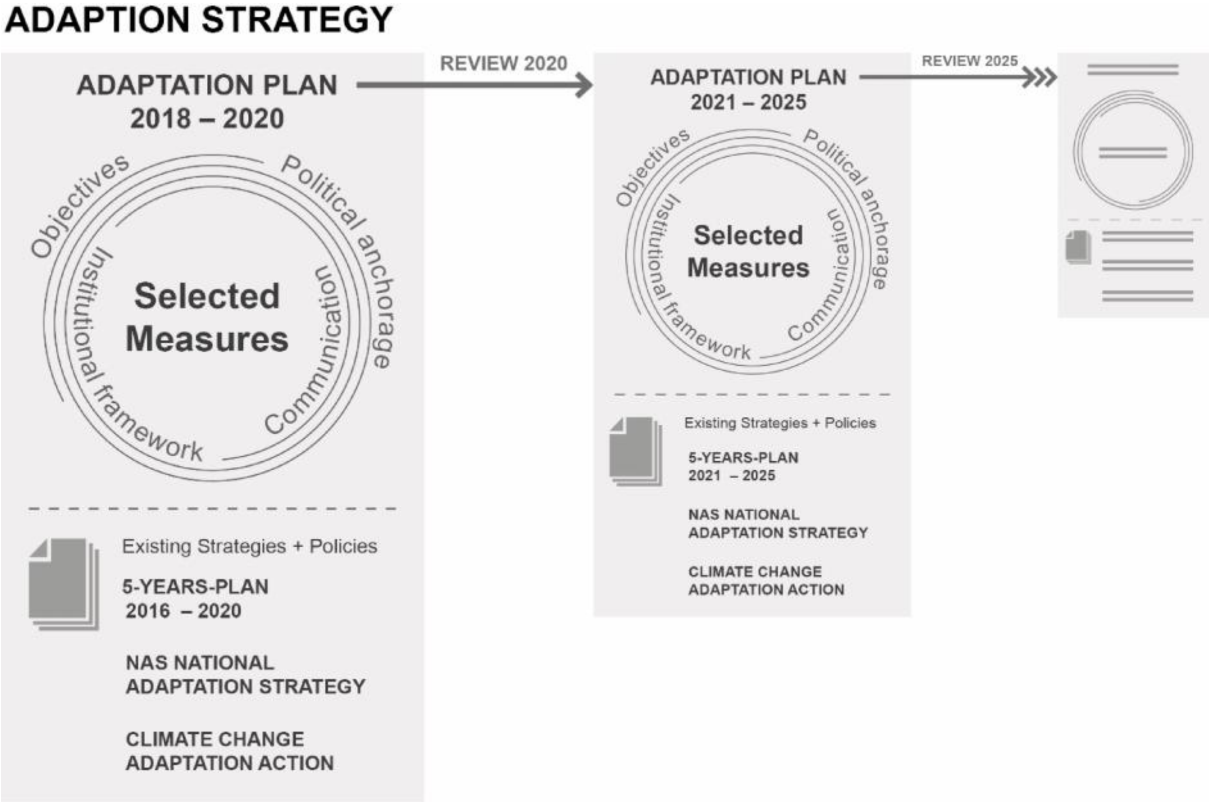


Figure 23: Long-term adaptation strategy principles

Results

The important elements of a long-term climate change adaptation strategy based on international experience and adapted to the situation in China have been described. Some of the most important challenges to implement such a strategy are the following:

— **Definition of** the **objectives of adaptation** backed by the important political forces so that the necessary steps for the assessment and implementation of measures to eventually meet these objectives can be made. The objectives should be reviewed when new knowledge regarding the impacts of climate change becomes available.

— Sufficient **coordination** between different sectors (e.g. water resources management and agriculture) and the corresponding institutions on national, regional (Province) and local (City) level, so that optimal measures can be addressed without unnecessary institutional barriers. In addition, the embedding in existing strategies and policies of these institutions is an important aspect to be considered.

— **Dealing with uncertainty**: An unbiased agreement between the important players regarding the degree of uncertainty of expected climate change impacts is important. The bigger the uncertainty about the impacts of climate change, the more important it is to define so-called “no regret" measures that permit to take action that are beneficial in different scenario options.

— **Capacity building**: Parties on all levels involved in planning should be sensitized and enabled to include climate change, just as other trends like demography, into their projects and the respective strategies that are developed.

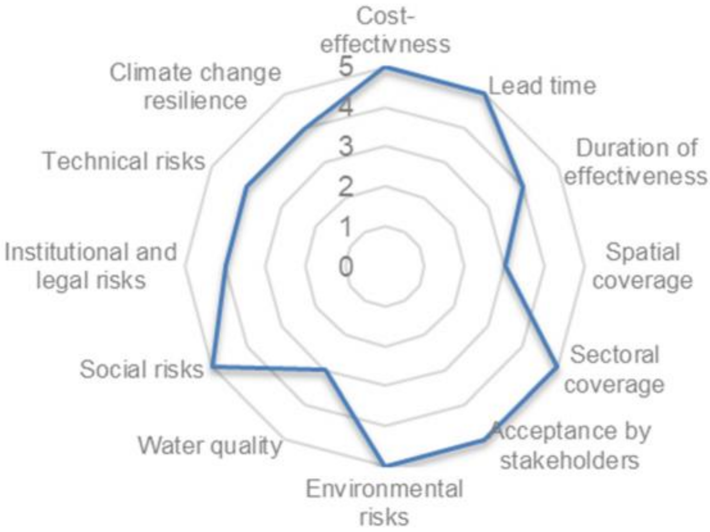
In addition, the most common methods to evaluate adaptation measures have been described, covering cost-benefit, cost-effectiveness and multi-criteria analysis. The choice of the suitable method depends on the aspects to be considered, the data and information available and the inherent uncertainties when assessing the measures, among others.

4.3.2 Case Study on Water Supply and Demand: Evaluation and Planning Tool for Lijiang City

Lijiang City is a fast-developing region that faces water management challenges typical to the JRB. The case study reveals the multi-dimensional challenges of Lijiang which do not only concern water quantity due to increasing water demand but also water quality and related ecosystem degradation. Agriculture is expected to be mostly affected under changing climate which will lead to more conflicts with public water services and the ecosystem.

A water allocation model (Water Evaluation and Planning Model, WEAP) was built and calibrated for 63 towns of Lijiang. The WEAP model considers 64 rivers, 78 reservoirs as well as 270 water demand sites for agriculture, industry and drinking water. The current and future water supply and demand situation of Lijiang was reproduced in the model which provide a fundamental basis for the 13th Five-Year Plan for Water Resources of Lijiang and will serve as a tool for the future water resources planning.

Lijiang is already planning a set of comprehensive measures to address the water challenges of today and the near future. The planning documents, policies and action plans in Lijiang have been assessed in terms of existing or already planned measures. Considering the cost-effectiveness, easiness of implementation, additional benefits and side effects, a multi-criteria analysis was conducted to assess the existing and additional adaptation options in urban and rural areas of Lijiang City. In total 52 (35 new, 17 planned or existing) adaptation options were evaluated.



Evaluation score for each aspect of the measure “optimization of existing reservoir management”

According to the evaluation results, the recommended measures for urban area are optimization of reservoir management, increase of storage volume of existing dams, aquifer recharge, storm water capture, storage and reuse, and education activities for improving water scarcity; the recommended measures for rural area are anti-seepage measures, optimization of reservoir management, optimization of irrigation schedule and improving cultivation techniques.

The results show that most the planned or existing measures are “grey infrastructure” projects such as reservoir construction, water diversion and new pumping stations. Given the increasing seasonal variability of water resources, the increase of water storage potential can be an effective measure to reduce water scarcity. However, the evaluation results show comparable or better performances of non-engineering measures that could complement or replace the engineering measures. Taking optimization of reservoir for example, the smart management of the water infrastructure could gain multiple benefits with low costs, rather than building a new reservoir in the nearby area. A combination of engineering measures with non-engineering measures such as smart infrastructure management system and demand side management measures (e.g. water saving initiatives, optimized crop selection and plant cultivation technologies) is recommended to be worked out in more detail that could be applied in the related water management practice.

Furthermore, it is recommended to investigate the potential nature-based solutions with blue and green infrastructures (mountains, forests, lakes, wet lands, groundwater etc.) given their multi-benefits on water storage, ecosystem protection, recreation and tourism.

Results Summary

This project has developed a **Water Evaluation and Planning Model** that reproduces the current and future water supply and demand situation in Lijiang and provides a useful basis for the Lijiang Water Bureau to properly and comprehensively deal with climate change and socio-economic developments. The project's research findings partially contributed to the "Lijiang Ecological Water Network Construction Planning" and "Lijiang Water Conservancy Development 13th Five-Year Plan".

The **analysis of existing or already planned measures** to reduce water scarcity in Lijiang City has shown that most of the planned measures are engineering measures on the water supply side. Non-engineering measures on the demand side and infrastructure management shows a good performance that could be considered as **additional adaptation options**. A set of additional adaptation options were recommended such as reservoir management, water saving and water reuse, optimized crop selection and cultivation technologies etc.

The water system and water issues in Lijiang are highly complex that concerns both water quantity and water quality with high seasonal variability. The following four pillars are recommended:

- **From grey to green**: to develop blue and green infrastructures as water storage and purifier rather than grey infrastructures if possible
- **From construction to smart management**: to conduct research on optimized management and maintenance of existing and planned infrastructures
- **From more water to more saving**: to explore the potential of measures on the demand side
- **Towards an integrated management system**: to enhance information exchange among sectors and administrative units in the river basin with a comprehensive monitoring network and a data sharing platform that allows for coordinated management and planning.

4.3.3 Case Study: Extreme Events

Climate change will lead to more frequent and more severe extreme flood and drought events in JRB. The work done in this project contributes to the improvement of the safety level against natural hazards in the future. The objectives were to elaborate a strategy to adapt to floods in Jinsha mainstream and flash floods as well as agricultural and hydrological drought events in the Jinsha River downstream area and to develop exemplary adaptation measures. Two equivalent methodological approaches were applied:

- Challenges for affected sectors and stakeholders were qualitatively analyzed and suitable adaptation measures were identified. New adaptation measures were identified and qualitatively evaluated and for high priority measures recommendations for their implementation were given.

- Existing protection and water supply measures in the different study areas were identified and quantitatively analysed regarding the impact of climate change on these measures and their flexibility and compatibility with climate changes. The different study areas selected were: Yibin City was selected for the analysis of flood protection measures; Panzhihua City, Central Yunnan Water Diversion Project and Xiangjiaba Irrigation Area Project for drought analysis. Finally, recommendations for the adaption of the existing measures and projects were given.

Communities (residents and buildings), agriculture, industry, critical infrastructure, energy production, waterways and ecosystems are mainly affected by climate change influenced extreme events. Its impacts are mainly financial losses due to various reasons and processes but also more fatalities due to flash floods. From 17 suitable flood and 26 drought management measures, eight mainly non-engineering measures were identified as of high priority. Technical measures are already widely spread in JRB, but there is a need to update the underlying mechanisms and data for decision making. The focus should lie on measures forming prerequisites for an IWRM such as hydro-meteorological monitoring, early warning system, drought monitoring and forecasting, optimization in reservoir regulation rules, hazard and risk mapping, improve participation practices, emergency response planning and drought and flood insurance. For drought management, it is also crucial to further develop the water demand and supply system (see chapter 4.3.2).

The current **flood control** system consisting of dikes and reservoirs protects Yibin City against a 50-year flood event. Flood volume in Yibin will increase in the near and far future. Under the assumption that safety discharge remains unchanged and considering that these two reservoirs have also other purposes than flood protection of Yibin it has been demonstrated that the current storage capacity of the reservoirs allocated for Yibin, Xiangjiaba and Xiluodu (1.46 billion m^3), needs to be increased.

To protect Yibin City from a mainstream flood in the far future, about 80 percent of the flood storage capacity of the reservoirs Xiangjiaba and Xiluodu seems to be needed. Today's safety discharge in Yibin is about 51'000 m^3/s. Considering climate change, approx. 58'000 m^3/s safety discharge in the near future and approx. 66'000 m^3/s safety discharge in the far future are expected to be needed. Since part of the retention volume of the two reservoirs must be retained to protect other cities, adaptive reservoir management is required.

Regarding **drought relief**, it is expected that the impacts of hydrological droughts on the three projects analyzed (see above) will be mitigated by the planned cascade reservoirs in the middle and lower reaches of JRB mainstream. Some climate change scenarios even show positive impact on the project considering water quantity. Reservoir regulation will play an important role when adapting to climate change specially to store water from the wet season to the dry season. Current drought management may be further developed by non-engineering measures.

Results

The **analysis of existing measures to reduce flood and drought risks** has shown that most of the planned measures are engineering measures for flood control and drought relief. Non-engineering measures received less attention. However, the evaluation of non-engineering measures such as monitoring systems, hazard and risk mapping etc. shows a good performance, so that such measures are recommended to be worked out in more detail and eventually implemented in addition to the already planned measures.

To protect **Yibin City** from a mainstream flood in the far future, about 80 percent of the storage capacity of the reservoirs Xiangjiaba and Xiluodu seems to be needed. Since part of the retention volume of the two reservoirs must be retained to protect other cities, adaptive reservoir management is required.

Regarding **drought relief**, it is expected that the impacts of climate change influenced hydrological droughts on the three projects analyzed (Panzhihua Urban Water Supply Project, Central Yunnan Diversion Project, Xiangjiaba Irrigation Area Project) will be mitigated by the planned cascade reservoirs in the middle and lower reaches of JRB mainstream.

To ensure or even improve the **safety level against natural hazards** under climate change, three main pillars should be followed:

— Development of the current natural hazard protection strategy towards an integrated hazard and risk management with risk based targets, defined safety levels and cost-efficiency analysis;

— Expansion of the current selection of risk management and adaptation measures, especially considering non-engineering measures and setting up ranking systems for the measures;

— Development of a more inter-sectoral planning and multi-level coordination dealing with natural hazards and climate change.

4.4 Knowledge Management

The knowledge management component focused on:

— Elaboration of **relevant** knowledge in line with the country and regional needs

— Elaboration of **state-of-the-art** and evidence-based knowledge for climate change adaptation and integrated river basin management

— Setting-up an interactive, virtual **platform** for sharing elaborates and findings as well as replicable and scalable know-how and do-how.

— Communication and dissemination **channels and opportunities** (conferences, events, etc.)

The JRB Project has built an international platform for knowledge and expertise exchange on water resources management and climate change adaptation. The platform not only presented project-internal documents but reached out to a broader community beyond the project borders. The platform is the most substantial contribution to the project's 'Knowledge Management' component.

On and through this platform, the project-specific work involving Swiss and Chinese expertise was shared and discussed. Research and analytical findings as well as more widely applicable lessons learned relevant to efforts to adapt to climate change and socio-economic development were published and presented. All relevant internal and external actors had access to the know-how and the do-how.

JRB Project activities and results have been promoted and disseminated through various channels and measures.

As one of the JRB project key communication features, the English version JRB website www.jinsha-adapt.org has been elaborated and gone online in March 2017, the Chinese version followed in June 2017.

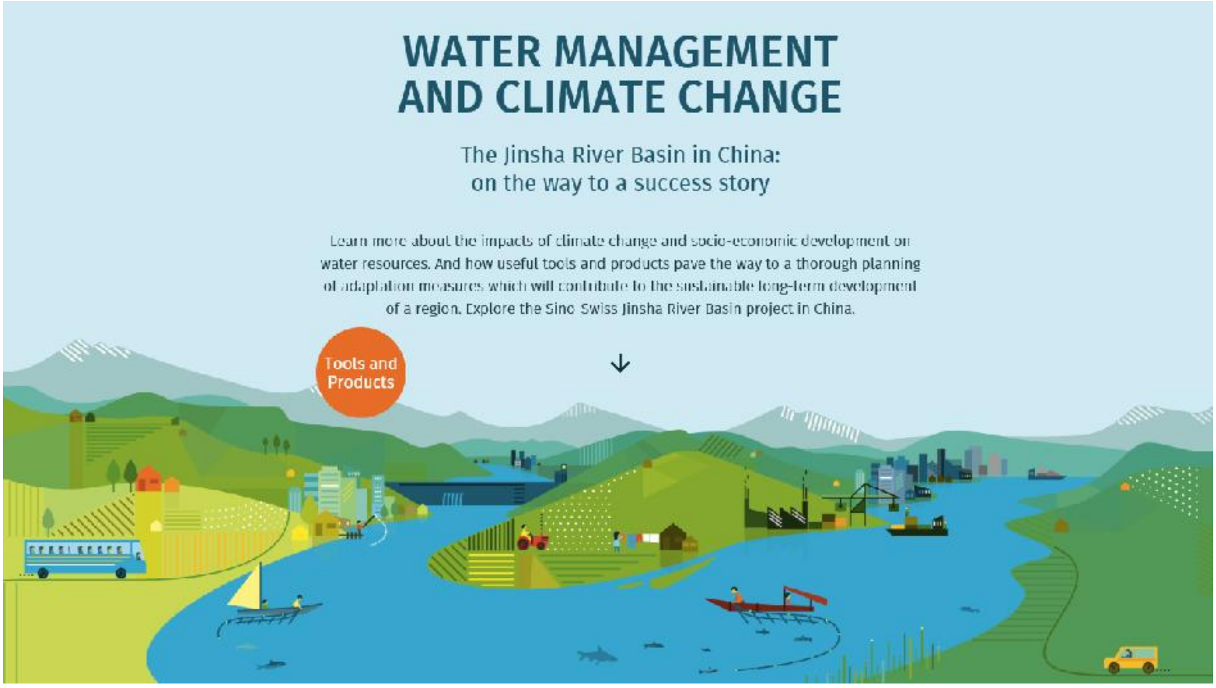


Figure 24: JRB website www.jinsha-adapt.org online since 2017.

The project team was present and actively presented project objectives and results during the following events and conferences, among others.

— Sino-Swiss High Level Dialogue Beijing in August 2016

— Mid-term Conference Lijiang in November 2016, incl. corresponding press releases

— International Conference on Water Resources and the Environment in Wuhan in January 2017

The project team was able to disseminate and communicate the elaborated knowledge through the following communication means:

— JRB project brochures and factsheets

— Technical publications on several research topics

— Videos on JRB project highlights and on Yulong Mountain monitoring installation

— CCTV documentary on climate change in China and Switzerland, shown in Swiss TV channel RTS

In addition, the JRB team contributed to the weADAPT platform under the title “Jinsha River Basin: Integrated Water Resources and Risk Management under Changing Climate”.

The communication and exchange with different water related departments in different regions (Yunnan Province, Lijiang City, Qinghai Water Resource Bureau, etc.) allowed for a practical exchange of experiences, contributing to opportunities for replication.

Through Study Tours to Switzerland and regular technical exchange, 40 Chinese experts and technical staffs from 6 departments have improved their technological and conceptual capabilities related to climate change and IWRM.

Swiss experts learned from different Chinese methods and approaches in those areas and from different scales and dimensions in China.

Results Summary

The JRB Project has built an **international platform for knowledge and expertise exchange** on water resources management and climate change adaptation. The platform not only presented project-internal documents but reached out to a broader community beyond the project borders.

As part of the knowledge management platform**,** project activities and project results have been **promoted and disseminated** within and beyond the project.

Technological and conceptual capabilities of Chinese and Swiss experts have been enhanced through study tours and permanent technical exchange.

5. Conclusions

During the 3 years JRB project Phase 1 period, Chinese and Swiss experts have created a solid fundament of research results and powerful and sound tools to enhance the water management practices for JRB, and therefore contribute to practical management needs of CWRC. Such fundament allows sufficient preparation of future implementation of IWRM in JRB and in other river basins in China.

As outlined in Chapter 3, relevant data has been collected and analysed, models have been built, trend analysis of socio-economic development has been performed, climate change scenarios have been analysed and their impact on water resources and extreme events have been assessed, and principles of long-term adaptation strategy including exemplary adaptation measures have been elaborated.

All these research achievements – together with enhanced cooperation skills and mutual trust among Chinese and Swiss experts - paved the way for substantial implementation work in the future.

The research results described in Chapter 4 illustrate significant impacts (partly in the sense of recommendations) on the technical level, mainly for institutes of CWRC involved, and partly for relevant stakeholders such as Lijiang Water Bureau (see Figure 25).

Figure 25: Based on the results described in previous Chapter 4, impacts on technical level for relevant stakeholders such as CWRC are outlined in Chapter 5.1.

The following Chapter 5.1 outlines such impacts of the research results created and described in Chapter 4.

In order to further improve Sino-Swiss cooperation and to make collaboration more efficient and successful in the future, lessons learned have been identified and displayed in Chapter 5.2.

5.1 From Results to Impacts

The impacts on technical level resulting from the JRB project Phase 1 are presented in the following table.

Results	Impacts on Technical Level
1 WATER CHARACTERISTICS AND DYNAMICS	
Severe natural hazard events such as droughts and floods hit large areas in JRB and caused partly a lot of fatalities and high losses in the past. Debris flows and landslides with severe consequences could be observed on a more local scale too.	Although the increase in the frequency of such incidents could not be deduced retroactively, there is already a need for action in the area of natural hazard management; these results can be used for communication at the political level.
The newly developed standardized **event registration platform** proved to be beneficial to analyze and visualize heterogeneous data sets.	The platform allows data input by different stakeholders using various archives and offers a central overview of former events, to allow opportunity of data sharing. It provides a basis for a comprehensive hazard management based on former events and enhances the process understanding.
	Risk management is enhanced because data on natural hazard events can be shared within various stakeholders. The digital event register is an opportunity for decision makers to further analyze and locate past and present events. Hence, the web-based platform shall be improved according to the local needs to register up-coming events. The tasks and responsibilities need to be defined.
	The platform provides an important basis for damage calculation and risk-based hazard management by recording event-related damage.
	The platform contributes to data standardization, which is an important basis for a uniform handling of natural hazards in the whole JRB by CWRC.
	The platform can be a useful tool for Research Center of Mountain Torrent Disaster Prevention and Control Engineering Technology to carry out research on mountain torrent disaster risk assessment.

Results	Impacts on Technical Level
Analysis of hydro-meteorological characteristics of the past shows that in general the **temperature** increased from 1960 to 2014 in all regions of JRB. In recent 50 years, **precipitation** didn't change significantly, with slight increasing trend.	The results are in line with other global warming analysis and confirm known tendencies of increasing temperatures and an uncertain development of precipitation.
	The results contribute to understand the characteristics of future meteorological and hydrological changes in JRB. They are very important basic information for any further research or planning work in future water resources management.
The **hydro-meteorological data analysis tool HydroAnalysis R-package** allows analysis of basic statistics including frequency and trends, drought intensity etc.	The HydroAnalysis R-package enhances analysis capacity at CWRC and allows further analysis of the temperature and precipitation trends observed in the near future regarding their effects on drought and flooding.
The glacier terrestrial observation station established in this project provides basic data support for understanding the impact of climate change. For the first time, glacier changes on Yulong Snow Mountain are **visualized by real-time monitoring**	The monitoring capacity of climate change impact to the mountainous water reservoirs has been enhanced. Based on newly obtained local weather, glacier and snow cover data, CRSRI and CAREERI improved the knowledge about the climatic preconditions and vulnerability to climate change in JRB.
	The observation station contributes to visualize the impacts of climate change to the public and the awareness raising.
The **snowmelt runoff model** showed that the contribution of snowmelt to runoff in the source region of Yangtze River is small. However, snow cover variations in different altitudinal and regional zones may have significant influence on the climate.	The contribution of snowmelt to runoff of Jinsha river in general is much less important than expected; precipitation is dominating the runoff of Jinsha River. This is an important finding for improving the water resources management in JRB with respect to forecasting for example. Nevertheless, the local importance of snowmelt in the upper region of JRB is still unclear.

Results	Impacts on Technical Level
	Satellite remote sensing is implemented as a method to better understand the spatial and temporal distribution of snow cover and precipitation. There is a potential to strengthen the capacity in satellite remote sensing analyses by setting up a Remote Sensing Center at CWRC.
	The opportunity to continue the research on snowmelt contribution should be balanced with eventual local problems: avalanches, local floods due to snowmelt, local water shortages due to lack of snowpack.
	The identification of contribution of snowmelt to runoff of upper Jinsha river could help decision-making on water management issues such as irrigation, flood control and hydropower generation, etc. The Snowmelt Runoff Model enhances analysis capacity at CWRC and allows further analysis of the response of glacier melting zone to climate change with long series of satellite data.
HMFM (RS Model), suitable for JRB with integrated large reservoirs, allows to realize hydrological forecasting on three time-scales. The model is incorporated into the existing hydrological forecasting system of BOH and forecast model system adaptability has further improved. Additionally, BOH experts have been trained to operate and maintain the forecast system.	The new HMFM allows BOH a more accurate and better supported forecasting of flood events to e.g. enhance emergency planning and reduce fatalities in the future.
	In the future, the new HMFM allows BOH to expand its application to a wide range of hydro-meteorological problems such as extension to the whole Yangtze basin, reservoir management for hydropower and irrigation optimization, (flash) flood alert or drought forecast.
	The new HMFM could be a shared tool for the integration of the current hydro-meteorological situation, of the future situation, and of the reservoir management effects. The extension of the system to the whole Yangtze basin is suggested.
	The model development has contributed to data centralization and has initialized a dialogue about data accessibility and data management policy.
	Open-data is a clear opportunity for better water resources management worldwide. It has been showed how data sharing is needed to improve technologies.

Results	Impacts on Technical Level
2 CLIMATE CHANGE SCENARIOS AND IMPACT ASSESSMENT	
A set of **climate change scenarios** for daily temperature and precipitation for the near future (2021-2050) and the far future (2070-2099) was elaborated on a grid covering the entire JRB.	This dataset is available for other studies, to assess the expected impacts of climate change. Only by considering a set of climate change scenarios based on different greenhouse gas emission scenarios and various global circulation models it is possible to estimate the uncertainly related to climate change.
For the lower reach of JRB, a **temperature rise** is expected. **Precipitation trends** are more uncertain including an increase in precipitation for the upstream and middle part of JRB, whereas the change for the lower reach is uncertain.	With little uncertainty regarding temperature trends in the next 30 – 40 years, there is a “robust” basis for the impacts mainly affected by temperature (e.g. irrigated crops when enough water for irrigation is available).
	Impacts dominated by the trend of increasing temperature must be taken seriously, as their uncertainly tends to be small.
	With the increase of temperature in the JRB, the area favorable for the cultivation of today’s most common crops will become larger, if water is not the main limiting factor. Furthermore, the suitable area is shifted towards the North and to higher altitudes.
	Where the amount of water from rain or irrigation limits the area under cultivation or the yield today, there are large uncertainties regarding the impacts of climate change. Further studies are needed when future trends in precipitation and water availability for irrigation are better known.
Lijiang is suffering from **water scarcity** today. The water conflicts in Lijiang will become more severe in the future. Agriculture sector will mostly be affected by climate change, resulting in impacts on ecosystem and domestic water supply.	Lijiang local authorities were informed about the climate change impacts on each sector. Departments from water, agriculture, housing and construction, forestry gave feedbacks on the challenges they may face in the future.
	The results of the Water Evaluation and Planning Model application for Lijiang are applied in important local planning documents.
	The key conclusions from case study Lijiang are mostly applicable in other regions in JRB basin. CWRC as the water management authority for this river basin is more familiar with the impact assessment approaches for potential upscaling.

Results	Impacts on Technical Level
Average annual runoff as well as runoff during the wet season are expected to increase significantly. The trend for runoff during the dry season is highly uncertain.	The higher available water volume in the Jinsha River generally offers opportunities for water resource management, e. g. more water is available for irrigation when the water can be stored appropriately.
	Rising discharge during the wet season offers additional opportunities for new water diversion projects or the enlargement of existing ones.
Intensity of extreme river and flash floods of a given return period will increase.	Due to river and flash floods, more casualties and financial losses must be expected in JRB in the future, if not sufficiently effective adaptation measures can be implemented giving additional protection and / or reducing damage for a given flood intensity. These findings now form the basis for raising awareness at the political level.
	With showed increasing risks the discussion whether existing safety targets will still be applicable in the future (e.g. regarding financial losses due to a Jinsha main river flood) and which remaining risks are acceptable has been started. New damage mitigation measures need to be discussed. Extension of insurance coverage to add resilience could also become more important.
The increase in future precipitation will decrease the frequency as well as intensity and duration of **meteorological droughts**. Due to higher evaporation, **hydrological droughts** are expected to become more frequent during the dry season. The expected increase in frequency, intensity and duration of **agricultural droughts** is subject to large uncertainty.	The decrease in meteorological drought offers opportunities, e. g. for agriculture, as more water is available in principle, at least during the wet season. This discussion has been initiated among the technical experts.
	Expansion of existing and/or new water diversion projects could be realised by evaluating these projects. The findings can be used for the planning of other projects.
	More frequent and intense hydrological droughts affect water delivery into water diversion infrastructure during certain periods in the dry season.
	With more frequent and intense hydrological droughts, water diversion projects will have a more limited capacity during the dry season in the future. The findings can be used for the planning of other projects.

Results	Impacts on Technical Level
	While rising temperature causes increased evaporation, plants tend to do photosynthesis in a more efficient way with rising CO_2 levels in the future. It is unclear which of the two competing effects prevails.
	The impact of climate change and the presumably scarcer water supply for irrigation make it very difficult to assess the impact on agriculture. The importance of further analysis regarding agricultural drought could be shown on the expert level.
Rising water temperature is regarded as the most important factor that affects **cold-water fish habitat**. However, hydroelectric power plants have a greater impact on fish ecology than climate change, because dams block fish migration paths to their optimal habitats in various phases of their life-cycle.	As the institute responsible for environmental impact assessments for hydropower plants in JRB, IHE's staff have been trained to conducts climate change impact assessment and impact of hydropower on fish habitat through habitat modelling.
	The application of fish habitat modelling is quite new in China. Through the capacity building on this case study, such approach will have a great potential to be applied in impact assessment and the elaboration of ecosystem restoration measures.
	The impact of hydropower plants on fish habitat has been demonstrated on a pilot scale, which offers opportunities to further investigate possible restoration measures such as optimized operation of hydropower plants.
	The study reveals the high risk of ecosystem degradation in Jinsha River that is in urgent need for immediate measures. Apart from implementation partners IHE and CWRC, more relevant stakeholders shall be involved and informed to enable more actions for ecosystem protection.

Results	Impacts on Technical Level
3 ADAPTATION STRATEGIES AND MEASURES	
A **long-term adaptation strategy** bases upon the methodologic framework of the adaptation strategy including overall objectives of the adaptation activities, political and institutional framework, capacity and awareness building as well as the concrete adaptation measures. The important elements of a long-term climate change adaptation strategy using on international experience and adapted to the situation in China have been described.	The international experience adapted to the JRB region permits to inform the involved stakeholders in the elaboration of the strategy and gives insights on the important components of the strategy.
	International experience shows that an integrated approach across different sectors (e.g. water resources management and agriculture) and the corresponding institutions on national, regional (Province) and local (City) level is necessary so that optimal measures can be addressed without unnecessary institutional barriers.
	A definition of the objectives of adaptation and their integration into existing strategies and policies backed by the important political forces is vital so that the necessary steps for the assessment and implementation of measures to eventually meet these objectives can be made. Those objectives have to be reviewed when new knowledge about the impacts of climate change becomes available.
	Capacity building regarding climate change impacts and possible adaptation measures is a key issue. Institutions responsible for planning on all levels should be able to include climate change, just as other trends like demography, into their daily work.

Results	Impacts on Technical Level
The **Water Evaluation and Planning Model**, developed in the project, provides a useful base for Lijiang Water Bureau to properly and comprehensively deal with climate change and socio-economic development.	CWRC as the planning and engineering institute mandated by Lijiang for water resources planning has been trained to develop and apply the model for water allocation planning.
	The model and its results influence the local water resources planning; e.g. "Lijiang Ecological Water Network Construction Planning" and "Lijiang Water Conservancy Development 13th Five-Year Plan", are partially based on the model results and findings.
	CWRC is planning to train the staff of the Lijiang Water Resources Bureau to apply the model in their daily management activities.
52 adaptation measures to **reduce water scarcity** in Lijiang were evaluated, including new options and planned measures in the existing planning documents. Measures with good performance were elaborated and recommended.	This is the first time that the water planning instruments such as Five-Year Plan of water resources management have been evaluated with the aspect of climate change adaptation.
	The evaluation approach can be upscaled in regular planning documents for other regions.
	A set of additional adaptation measures such as optimized reservoir management were recommended to CWRC and Lijiang local authorities to be further investigated.
	Suggestions on additional management instruments such as river basin management plan, groundwater protection and utilization plan will be submitted to CWRC and Lijiang local authorities.

Results	Impacts on Technical Level
Analysis of existing **measures to reduce flood and drought risks** has shown that most of the planned measures are engineering measures for flood control and drought relief. Non-engineering measures such as monitoring systems, hazard and risk mapping etc. need more attention.	Regarding integrated water resources and risk management, a stronger focus on non-engineering measures will be necessary in future.
	A stronger focus on non-technical measures such as planning and organizational measures will make it possible not only to protect oneself but also to avoid and mitigate risks before thinking about protection.
To protect Yibin City from a mainstream flood in the far future, about 80 percent of the flood storage capacity of the reservoirs Xiangjiaba and Xiluodu seems to be needed. Since part of the retention volume of the two reservoirs must be retained to protect other cities, dikes and embankments at Yibin need to be enlarged to enable 66’000 m^3/s safety discharge and non-engineering measures are recommended to help control floods.	Optimization of reservoir cascade regulation can support the containment of mainstream floods, but further measures - including non-technical measures - are necessary and in particular a stronger focus on risk-based flood management, within which hazard and risk mapping also plays an important role for example.
	The applied approach to analyze climate change compatibility of existing measures can be transferred to other flood prone areas and their protection system.
Regarding **drought relief**, it is expected that the impacts of climate change influenced hydrological droughts on the three projects analyzed will be mitigated by the planned cascade reservoirs in the middle and lower reaches of JRB mainstream.	Reservoir regulation will play an important role when adapting to climate change specially to store water collected in the wet season for the dry season.
	The applied approach to analyze climate change compatibility of existing water projects can be transferred to other river basins.
	Current drought management may be further developed by non-engineering measures such as a drought monitoring and forecasting system or risk mapping.

<table>
<tr><th>Results</th><th>Impacts on Technical Level</th></tr>
<tr><td rowspan="4">To ensure or even improve the safety level against natural hazards under climate change, three main pillars should be followed:
Development of the current natural hazard protection strategy towards an integrated hazard and risk management with risk based targets and defined safety levels;
Expansion of the current selection of risk management and adaptation measures, especially considering non-engineering measures and setting up ranking systems for the measures;
Development of a more inter-sectoral planning and multi-level coordination dealing with natural hazards and climate change.</td><td>This project proposes additional adaptation measures to develop a more risk-based management of natural hazards, such as a monitoring and forecasting system for droughts, a flash flood forecasting system, hazard and risk mapping for risk-based spatial planning and risk-based action planning, where cost-benefit analysis plays an important role.</td></tr>
<tr><td>The general recommendations are also valid for other river basins and hazard management projects.</td></tr>
<tr><td>This project provides concrete examples of how to improve inter-sectoral and multi-level coordination in JRB.</td></tr>
<tr><td>Regarding integrated water resources and risk management, a stronger focus on risk based decision making and cost-benefit analysis of planned measures will be necessary in future.</td></tr>
<tr><td></td><td>A stronger focus on cost-benefit analysis in measure planning makes it possible to take greater account of economic and ecological aspects and thus to develop further in the direction of integrated water resources management.</td></tr>
</table>

Results	Impacts on Technical Level
4 KNOWLEDGE MANAGEMENT	
As part of the knowledge management platform, **project activities and project results have been promoted and disseminated** within and beyond the project. Quality and relevance of project outputs were ensured with quality assurance processes	Knowledge management did not only consider the processes within the project, but it also created outreach beyond the project borders – in view of replication of experiences, but also in view of multiplication of the knowledge elsewhere.
	Technological and conceptual capabilities of Chinese and Swiss experts have been enhanced through study tours and technical exchange.
	Chinese project partners were continuously involved in elaboration and quality improvement of scientific outputs. Methodical competencies of Chinese partners were improved.
	The research results of this project include different in-depth knowledge of the scientific aspects of water management and climate change. These can be used as good examples and experiences for other regions and river basins on technical and – in the future - policy level. The realized approach as well as the developed models and tools can be transferred to other regions and help to understand the impact of climate change in other river flows.

5.2 Lessons Learned

Sino-Swiss cooperation in the field of integrated water resources and risk management and climate change has now some years of tradition. Collaboration skills and mutual trust has been enhanced during this time. In order to make collaboration more efficient and successful in the future, lessons learned have been identified and displayed as follows.

— Data access and sharing was of crucial importance for the project. Complex models can only run with sufficient data, otherwise simple methods are enough. Trustful relationships had to be built and could finally help to solve data issues. At the end of the project, a large part of the necessary data had been made available to Swiss experts and other Chinese teams.

— A robust knowledge base is the key to implement optimized adaptation measures to climate change. With many stakeholders involved, it has been a huge challenge to gain a comprehensive overview of the quality and quantity of existing data (e.g. local weather, natural hazard event or river runoff). Due to restrictions, some institutes cannot share data. It proved to be a necessary precondition to establish specific web-based data platforms (e.g. Jinsha Share and Event Registration Platform) to facilitate the data-exchange and gain a knowledge about the uncertainties.

— Through close cooperation and exchange during workshops, study tours, telephone, WeChat etc., language challenges and mentality differences could have been successfully overcome.

— During the entire project period, concerns about environmental issues have grown on the Chinese side, e.g. illustrated at Mid-term Conference in Lijiang.

— The climate change impact on water resources was and is still a new topic for the public in China. The awareness raising of climate change impacts will remain a continuous process throughout the project implementation with stakeholders and decision-makers.

— Uncertainties about climate change impacts and other future developments have been addressed in the research work of the project, they will remain a challenging issue when trying to influence decision-making and shaping policies and strategies.

— The planning periods in China (5 to 15 years) may create conflicts with the long-term impacts of climate change and the long-life span of water infrastructures. The decision to consider two future time periods (near future 2021-2050, far future 2070-2099) in the project was the result of intense discussions in the project team and with stakeholders, to ensure the scientific value but also the practical use of the project results.

— Raising water issues in China are multi-dimensional and complex. This project offered learning processes for both Chinese and Swiss teams for assessing and providing solutions in interesting case studies.

A1 Deliverables

All the reports, minutes and notes listed below are uploaded to Jinsha_share platform.

Technical Reports

JRB Technical Workshop No. 1	Workshop Report – Master Document, incl. Annex Technical Group Meetings	May 2015
Output 1.1	Understanding the characteristics of historical flood and drought disaster events (i.e. extreme events), Report No. 14130691.1	13.04.2015
	Meeting Minutes: Technical group meeting	24.03.2015
	Understanding the characteristics of historical flood and drought disaster events, Technical Report	05.05.2015
	Meeting Minutes, Technical group meeting	26.05.2015
	Technical Group Report of Extreme Event Registration	26.02.2016
	Technical Group Report, Technical Workshop No. 3	06.04.2016
	Meeting Minutes: Technical group meeting	17.05.2016
	Understanding the characteristics of historical flood and drought disaster events (i.e. extreme events); Final Report	June 2016
Output 1.2	50 years of hydro-meteorological data of JRB is compiled and analyzed; Final Report	March 2016
Output 1.3	Proposal Output 1.3. Report No. 4130692.1	30.01.2015
	Meeting Minutes of 1st Technical Group Meeting	25.03.2015
	Meeting Minutes of Field Survey	29.03.2015
	Technical Report to Output 1.3	05.05.2015
	Mission Report: Installation of terrestrial Monitoring Station at Yulong Snow Mountain	02.09.2016
	Maintenance Manual Yulong Station, Report No. 14130693	28.04.2017
	Repair of the Yulong Station, Proposal	28.07.2017
	Terrestrial Glacier Monitoring Station at Yulong Snow Mountain, Final Report	30.09.2017
	Snow Cover Mapping and Snowmelt Runoff Simulations for the Upper Jinsha River Basin based on Satellite Remote Sensing Data and the Snowmelt Runoff Model SRM, Final Report	October 2017
Output 1.4	Overview of Aquatic Ecosystem in Jinsha River; Final Report	March 2017
Output 1.5	Development of a short to long term hydro-meteorological forecasting model; Final Report	November 2017
Output 1.6	Current Water Supply and Demand Situation of Lijiang Municipality; Final Report	March 2017
Outputs 2.1/2.2	Climate Scenarios for the JRB; Final Report	December 2016
Outcome 2	Workshop on CC Impact Assessment; Workshop Report	June 2016
Output 2.3	Hydrological simulations with climate change scenarios; Final Report	August 2017

Output 2.4	Climate Change Impact Assessment on Runoff, Hydropower and Water Balance, Final Report	November 2017
Output 2.5	Analysis of the impacts of climate change on flood and drought occurrence; Final Report	November 2017
Output 2.6	Impact of Climate Change and Hydropower on Aquatic Ecosystem; Final Report	October 2017
Output 2.7	Assessment of Climate Change Impacts on Sectors and Stakeholders and Identification of Climate Challenges and Opportunities; Final Report	October 2017
Output 3.1	Experiences from Adaptation to Climate Change in River Basins, Final Report	September 2016
Outcome 3	Workshop on CC Adaptation Measures and Strategies; Workshop Report	March 2017
	Workshop No. 2 on CC Adaptation Measures and Strategies; Note for the PLU Meeting No. 4 (incl. Technical Audit),	June 2017
Output 3.2	Adaptation Strategies and Measures for Water Supply and Demand in Lijiang; Final Report	November 2017
Output 3.3	Adaptation Strategies and Measures for Flood Management and Drought Relief; Final Report	November 2017
Output 3.4 / Outcome 3	Documentation of Adaptation Approach and Methods for Assessing Adaptation Measures; Final Report	November 2017
JRB Project	Final Report, English and Chinese Versions	April 2018

Study Tours

Study Tour No. 1	Mission Report	May 2015
Study Tour No. 2	Mission Report	November 2015
Study Tour No. 3	Mission Report	May 2016
Study Tour No. 4	Mission Report	October 2016
Study Tour No. 5	Mission Report	October 2017

Project Steering Committee PSC / Project Leading Unit PLU / Project Implementation Unit PIU

PSC Meeting No. 1	Protocol	June 2015
	JRB Progress Report	June 2015
PSC Meeting No. 2	Protocol	June 2016
	Addendum to Protocol	September 2016
	Operational Report Year 1	June 2016
	Operational Report Year 1	Revision August 2016
PSC Meeting No. 3	Protocol	July 2016
	Operational Report Year 2	June 2017

PLU Meeting No. 1	Protocol	January 2016
PLU Meeting No. 2	Working Meeting Protocol	August 2016
PLU Meeting No. 3	Meeting Note	November 2016
PLU Meeting No. 4	Note for the PLU Meeting No. 4 (incl. Technical Audit)	June 2017
PIU Meetings	Several Meeting Notes	2015, 2016, 2017

A2 Chinese and Swiss Team

Jinsha River Basin project is a Sino-Swiss cooperation involving the public and private sectors of both countries.

Sino-Swiss Steering Committee

中华人民共和国水利部
The Ministry of Water Resources of the People's Republic China

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Agency for Development
and Cooperation SDC

Chinese Partners

CWRC
NHRI Since 1935 南京水利科学研究院
CAREERI
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Swiss Partners

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